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TILDEN FOUNDATIONS

Curly Grain Cypress—Sugi Finish

Figured Red Gum

Curly Grain Douglas Fir

FIGURES OF WOOD

LUMBER AND ITS USES

BY

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ILLUSTRATED

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LUMBER AND ITS USES

THE STRUCTURE OF WOOD

FEW of either the makers or the users of forest products—and this includes all of us—have any conception of the real structure of the material with which they deal. The botanist tells one tree from another by differences in foliage, flowers, fruits, and bark; the microscopist, by differences in the structure and arrangement of cells which may be visible only through a high-powered microscope; the woodsman, by general notions of appearance; the carpenter, by characteristics of texture and weight learned in the working of wood; and the ordinary user, by any combination of these methods that may have impressed him in the course of his experience. While the botanist and the microscopist use scientifically exact means of determining species of trees and kinds of wood, the lumberman, the cabinet-maker, and the man in the street use methods which, while unscientific and even impossible to describe, nevertheless often suffice for their own particular needs.

Wood is bought, sold, and used with far less knowledge of its composition, strength, stiffness, density, and other qualities than is any other substance that enters largely into our daily life. A steel rail is made according to a formula prepared by the metallurgist; there are standard mixtures for cement and concrete; the physical properties of metals and stone are accurately known; but even the best grading rules of the manufacturers are only approximations to the actual values of the different classes of lumber. To a large extent this is an unavoidable condition. A tree is not made according to any chemical or mechanical formula. It is the product of soil, moisture, and sunshine in constantly varying combinations. Buffeted by storms and subjected to extremes of heat and cold, drouth, and flood for a century or more, each year's growth is different from that which precedes or follows; and the resulting mass of wood is a highly complex substance of which we know far too little.

But the problems of modern construction and utilization demand that our knowledge of wood be increased in scope and accuracy. Therefore the timber-testing engineer, with his ponderous machines, determines the strength, stiffness, and elasticity of beams of a specified size and kind; the timber-treating expert, with cylinders and pressure pumps, finds out the best means of impregnating wood with creosote, zinc chloride, and other decay-preventing substances; the pulp-

maker cooks and grinds different woods to get the best kind of paper; the chemist puts wood into his retort, and gets alcohol, turpentine, acid, and many other products; but all of these problems go back to the fundamental one of the structure of the wood itself.

Porous and Non-Porous Woods

The unit of woody structure, as of all vegetable and animal growth, is the cell; and the scientific classification of woods is based upon the properties and combinations of these ultimate units. When cross-sections of certain woods are examined, they are seen to contain relatively large, irregularly placed openings called "pores." Other woods, even under the microscope, show no such openings. A natural, fundamental division, therefore, is into "porous" and "non-porous" woods. Of porous woods, the common hardwoods are familiar examples; while the pines, firs, spruces, cedars, etc., are non-porous. Again, the porous woods are divided into two classes according to the arrangement of the pores in the yearly ring of wood. In some woods, very large pores develop early in the season; while only small pores or none at all appear later, so that a cross-section of such a wood shows, even to the naked eye, concentric circles of openings. These woods are called "ring-porous" woods. In other woods, pores of small and approximately equal size are scattered throughout, with little if any discernible grouping. Such woods are called "diffuse-porous"

woods. Common ring-porous woods are ash, oak, elm, and hickory. Among the diffuse-porous woods are birch, beech, basswood, maple, and walnut.

Pith Rays

In addition to the cells whose length is parallel to the trunk of the tree, wood also contains other layers of cells of a different character whose length is at right angles to the trunk of the tree. These cells occur in thin sheets radiating from the bark toward the pith, and form what are called the "pith rays" or "medullary rays" of wood. They are best seen on a quartered section, and are what gives the beautiful, flaky appearance to quartered oak and sycamore. The pith rays are less conspicuous in beech, maple, and birch, and are scarcely or not at all visible to the naked eye in the pines and many other woods.

Springwood and Summerwood

When growth begins in the spring, the new cells are large and thin-walled. As the season progresses, smaller and thicker-walled cells are produced, until the last growth of the summer is much denser than the spring growth. It is this contrast between early spring and late summer wood that enables us to distinguish the rings of yearly growth upon a stump or cross-section of a piece of timber. The transition from the large, thin-walled cells of spring to

the small, thick-walled cells of summer may be abrupt, as in the yellow pines, or very gradual, as in the white pines and the firs. In the former, the bands of dense wood are very conspicuous; in the latter, they are sometimes scarcely visible to the naked eye. Counting these annual rings on the stump affords an easy and practically accurate means of determining the age of our common trees. Trees which grow in warm climates where there are no fixed cycles of growth and inactivity, do not develop annual rings.

Among the softest, most easily worked woods are white pine, spruce, basswood, and yellow poplar. The first two are non-porous; the last two, diffuse-porous. In all, the transition from springwood to summerwood is very gradual; the cells are thin-walled; and the texture is remarkably uniform. None of these woods, however, has great strength. Hickory and osage orange, two of our strongest native woods, contain such large pores that, at first glance, one might think they were not strong; but closer examination under the microscope shows a multitude of very small, thick-walled cells which are the source of their remarkable strength.

Sapwood and Heartwood

A cross-section of the trunk of a living tree will show on the outside a belt of wood of varying width, in which the vital processes of the

tree are carried on. Within this belt is a cylinder of older cells, no longer of importance in the growth of the tree, whose function is chiefly that of a support for the great weight of the crown. The outer belt is called the "sapwood;" and the inner cylinder, the "heartwood." The sapwood is light-colored. When tapped, sap flows from it, as in the maples; or resin, as in the pines. As the cells become older, their functions are assumed by newer ones closer to the bark. The living matter of the older cells is gradually changed by deposits of mineral or other matter, generally of darker color, which produce what is called "heartwood."

It is the dark, richly colored heart of birch, red gum, black walnut, red cedar, redwood, dogwood, persimmon, and other trees that yields the beautiful woods for which these species are noted.

Heartwood develops very early in some species, like black locust, osage orange, and catalpa, and very slowly in other species. Black walnut is likely to reach an age of fifty years before much dark heartwood—the valuable portion of the tree—is formed.

The heartwood in some species—basswood and hemlock, for example—is often not clearly distinguishable from the sapwood, and the older cells seem to retain the ability to transmit sap. That the outer portion of the trunk is the main seat of vital activity, however, is proved by the

continued growth of trees for many years after they become hollow at the base through decay.

Heartwood is generally heavier than sapwood, and fully as strong if equally free from defects. Moreover, it is usually much more resistant to decay. On the other hand, since its cells are more open, sapwood usually absorbs wood preservatives better than heartwood.

The Figure of Wood

The varying combinations of cells of different kinds, of springwood and summerwood, of heartwood and sapwood, of slow and rapid growth, of knots, burls, dormant buds, and spiral or "curly" grain, produce the many beautiful and characteristic figures which give wood a unique position as a decorative material. These natural variations are still more accentuated by methods of sawing and working, so that the artificer of wood can produce an endless variety of effects without monotony.

Weight and Strength

Other factors being equal, the strength of wood is roughly proportional to the dry weight. Hence heavy, thick-walled cells are stronger than light, thin-walled cells; and summerwood stronger than springwood. Given two pieces of wood of the same kind and equally free from defects, the one which is the heavier and contains the larger proportion of summerwood is the stronger. This affords a ready and fairly

accurate means of selecting certain kinds of timber. Comparisons of the weight and strength of a number of woods are given on page 19.

What the Microscope Shows

Cross-sections of four common woods, magnified to the same degree, are shown in the illustrations. Since the magnification is the same throughout, the character and size of the cells in these woods are readily compared. Balsam fir and longleaf pine are non-porous woods; birch, diffuse-porous; and oak, ring-porous. In longleaf pine, the transition from spring to summer wood is abrupt, resulting in alternating light and dark bands. In the other woods, the transition is very gradual, and often not conspicuous to the naked eye. Comparing size and thickness of cell walls, it is seen that, for the entire season's growth, the cells of balsam average the largest and thinnest-walled; those of longleaf pine rank next; those of birch next; and that the oak cells are the smallest and thickest-walled. The ragged openings in the longleaf pine are not pores; they are ducts in which the resin forms.

PHYSICAL PROPERTIES OF WOOD

THE physical properties of wood which determine its usefulness, vary with the species, the rate and place of growth, the seasoning condition, and even with individual trees. Two trees are no more exactly alike in either botanical or physical characteristics than are two human beings; hence tabulations purporting to compare the weight, strength, stiffness, or other properties of various woods can be accepted as true only within rather wide limits, and this caution especially applies to the tables in this chapter.

Similar variability, however, is found in other construction materials; and the factors of safety allowed for their use are as great as, or greater than, those for wood.

The commercial terms, "hardwood" and "softwood" do not correspond to the physical characteristics of hardness or softness, and are of little real value in this respect. As ordinarily used, the term "softwood" is given to all trees of the family that the botanists call "coniferous" or "needle-leaved." These are the pines, firs, spruces, hemlocks, cypress, larch, redwood, tamarack, cedars, etc. The term "hardwood" is commonly applied to the species which botanists call "broad-leaved," represented by the oaks, maples, hickories, elms,

ashes, basswood, beech, birches, walnut, etc. The slightest experience with wood shows that these terms give little indication of the physical properties of the species to which they refer. There are hardwoods softer than the so-called softwoods, and softwoods harder than the so-called hardwoods, although as a group the softwoods average much softer than the hardwoods. Comparisons of this sort may be readily made from the tables given in this chapter.

Useful Properties of Wood

The properties of wood most important from the standpoint of the ordinary user are: Weight, strength, stiffness, toughness, hardness, and shrinkage. For some purposes, light weight and stiffness are essential where neither great strength nor toughness is required. For other purposes, strength is by far the most important consideration; and for still other uses, hardness is the determining quality. In some places, it makes little difference how much a piece of wood shrinks; in other places, even a little shrinkage will impair the usefulness of the article. Toughness is essential for many purposes, but not at all necessary for other uses. There is, thus, a very wide range in the requirements of wood users, which is met by a great diversity of species and physical properties.

The statements in this chapter regarding the physical properties of wood are based upon a series of tests by the United States Forest Serv-

ice to obtain data for the comparison of the more important species. All the figures are derived from tests of small, clear pieces of wood in green condition. Tests of this character afford the best basis for the comparison of various woods; but the figures obtained in this manner do not correspond with the results of tests upon larger-sized material or upon material in the various stages of seasoning ranging from air-dried to kiln-dried. Neither is it safe to assume that the rank of the several species as to weight, strength, stiffness, toughness, and hardness is exactly as indicated by the tables, since many factors such as growth, situation, length of fiber, etc., influence the properties of a given piece of wood. In a broad sense, however, the figures do have a real comparative value, and they are of especial interest since it is the first time that they have been presented in this fashion.

Weight

The weight of wood is usually expressed by a comparison of the weight of a given volume of wood with that of an equal volume of water, or by what is known as "specific gravity." If the specific gravity of a certain kind of wood is stated as .30, it means that a given volume of this wood weighs .30 times as much as an equal volume of water. Since a cubic foot of water weighs 62.5 pounds, a cubic foot of wood of specific gravity .30 weighs $.30 \times 62.5 = 18.75$

pounds. A piece of wood whose specific gravity is .50 weighs $.50 \times 62.5 = 31.25$ pounds per cubic foot. Similarly, the weight per cubic foot of any kind of wood may be quickly ascertained when the specific gravity is known.

Table 1 gives the specific gravity of a number of hardwoods and softwoods when "oven-dry," arranged in order from the lightest to the heaviest in each class. By "oven-dry" is meant the condition produced by drying wood at a temperature of 212° F. (the boiling point of water) until it ceases to lose moisture.

The average specific gravity of the softwoods is .39; and that of the hardwoods, .53; hence these hardwoods average 36 per cent heavier than the softwoods. Several of the softwoods are lighter than any of the hardwoods; but the heaviest of the softwoods, as larch, shortleaf pine, tamarack, and longleaf pine, are heavier than many hardwoods. On the other hand, Table 1 contains 17 hardwoods which are at least twice, or more than twice, as heavy as the lightest of the softwoods. Any of these woods, of course, is much heavier when green. For example, the weight of thoroughly dried northern white cedar is 18 lbs. per cubic foot, compared with 28 lbs. when green; and that of osage orange, 48 lbs. per cubic foot, compared with 62 lbs. when green.

STRENGTH OF WOODS

It is most important that the users of timber

TABLE 1

Specific Gravity of Various Woods

(Test pieces "oven-dry")

SOFTWOODS

Cedar, Northern White	.29	Fir, Amabilis	.38
Cedar, Western Red	.29	Hemlock, Eastern	.38
Spruce, Englemann	.31	Spruce, Red	.38
Fir, Alpine	.31	Pine, Table Mountain	.39
Spruce, White	.32	Douglas Fir	.42
Redwood	.35	Hemlock, Black	.42
Fir, White	.35	Hemlock, Western	.42
Pine, Sugar	.36	Pine, Norway	.44
Pine, White	.36	Cypress	.45
Cedar, Incense	.36	Larch, Western	.46
Pine, Western Yellow	.37	Pine, Shortleaf	.48
Pine, Lodgepole	.37	Tamarack	.49
Fir, Grand	.38	Pine, Longleaf	.53

Average Specific Gravity of Softwoods..... .39

HARDWOODS

Buckeye, Yellow	.33	Hickory, Nutmeg	.56
Willow, Black	.33	Witch Hazel	.56
Basswood	.34	Maple, Hard	.56
Aspen, Largetooth	.35	Oak, Tanbark	.56
Butternut	.36	Oak, Yellow	.56
Cherry, Red	.36	Oak, Red	.57
Elm, White	.43	Elm, Rock	.58
Gum, Red	.43	Oak, Bur	.58
Maple, Silver	.44	Birch, Sweet	.59
Cucumber	.44	Oak, Post	.59
Sumac	.45	Oak, White	.60
Sycamore	.45	Laurel, Mountain	.62
Ash, Black	.47	Hickory, Bitternut	.62
Cherry, Black	.47	Hickory, Water	.63
Elm, Slippery	.47	Hickory, Shagbark	.63
Tupelo	.48	Hickory, Big Shellbark	.63
Hackberry	.48	Oak, Swamp White	.64
Ash, Pumpkin	.49	Dogwood	.64
Maple, Red	.49	Hickory, Mockernut	.65
Ash, Blue	.53	Hickory, Pignut	.66
Ash, Green	.53	Locust, Black	.66
Beech	.54	Locust, Honey	.70
Ash, White	.55	Osage Orange	.76
Birch, Yellow	.55		

Average Specific Gravity of Hardwoods.... .53

have some idea of the resistance which the common woods offer to cross-breakage, to crushing, and to what is called "shearing." The cross-breaking strength of a piece of timber is the force which is required to break it when it is supported at the ends and loaded between these points. The crushing strength is the resistance which a stick offers to crushing when loaded as in the case of a railroad tie. The shearing strength is the resistance offered to a force which tends to make the fibers shear or slide past one another.

Breaking or Bending Strength. The cross-breaking strength of timber is tested in the laboratory by placing a stick on supports at each end, and loading it at a uniform rate until it breaks. Accurate notation is made of the size of the stick; length of span; the amount of deflection, or the extent to which the stick bends, under various loads; and the weight which finally breaks it. From this information, several factors are determined—one, which best represents the resistance to cross-breakage, being called the "modulus of rupture" and expressed in pounds per square inch.

The cross-breaking strength of a piece of wood varies directly with the length of the stick, and inversely with the square of the thickness; thus, if a weight of 400 pounds breaks a stick 4 feet long, a weight of 200 pounds will break a stick 8 feet long, all other factors being the same. On the other hand, if a weight of

Red Oak Log

Sugar Pine Log

CROSS-SECTIONS OF LOGS, SHOWING ANNUAL RINGS, HEARTWOOD, AND SAPWOOD

Plate 2—Lumber and Its Uses

No. 1

No. 2

Cross-Sections of Loblolly Pine, Showing Variations in Manner of Growth

No. 1—Containing large proportion of springwood; No. 2—Containing large proportion of summerwood. No. 2 is the stronger.

Sapwood and Heartwood in Loblolly Pine

TABLE 2

Modulus of Rupture of Various Woods

Test pieces 2 in. square, 28 in. span, of green, clear wood—
Average results

SOFTWOODS

Spruce, Englemann	4,200	Cedar, Incense	6,040
Cedar, Northern White	4,250	Fir, Grand	6,090
Fir, Alpine	4,450	Hemlock, Eastern	6,180
Cedar, Western Red	4,750	Douglas Fir	6,340
Pine, Western Yellow	5,090	Pine, Norway	6,430
Pine, Lodgepole	5,150	Fir, Amabilis	6,570
Spruce, White	5,200	Redwood	7,000
Pine, Sugar	5,270	Cypress	7,110
Pine, White	5,310	Tamarack	7,170
Pine, Table Mountain	5,700	Larch, Western	7,250
Spruce, Red	5,710	Hemlock, Western	7,290
Fir, White	5,970	Pine, Shortleaf	7,710
Hemlock, Black	6,030	Pine, Longleaf	8,630

Average Modulus of Rupture of Softwoods....6,040

HARDWOODS

Willow, Black	3,340	Beech	8,160
Buckeye, Yellow	4,820	Witch Hazel	8,280
Basswood	4,860	Laurel, Mountain	8,440
Cherry, Red	5,040	Birch, Sweet	8,590
Butternut	5,370	Birch, Yellow	8,600
Maple, Silver	5,820	Dogwood	8,790
Sumac	5,845	Hickory, Nutmeg	9,060
Aspen, Largetooth	5,850	Maple, Hard	9,060
Ash, Black	6,000	Elm, Rock	9,430
Hackberry	6,210	Ash, Blue	9,650
Sycamore	6,300	Ash, White	9,853
Gum, Red	6,450	Oak, Swamp White	9,860
Elm, White	6,950	Ash, Green	10,040
Oak, Bur	7,180	Hickory, Bitternut	10,280
Tupelo	7,380	Hickory, Big Shellbark	10,490
Oak, Post	7,380	Oak, Tanbark	10,710
Cucumber	7,420	Hickory, Water	10,740
Ash, Pumpkin	7,600	Hickory, Shagbark	10,870
Elm, Slippery	7,710	Hickory, Mockernut	11,560
Maple, Red	7,890	Hickory, Pignut	11,850
Oak, Red	8,000	Locust, Honey	12,360
Cherry, Black	8,030	Osage Orange	13,660
Oak, Yellow	8,110	Locust, Black	13,800
Oak, White	8,160		

Average Modulus of Rupture of Hardwoods...8,350

400 pounds breaks a stick 2 inches thick, it will require a weight of $400 \times 2^2 = 1{,}600$ pounds to break a stick of the same material 4 inches thick.

The modulus of rupture for green sticks of clear wood is indicated in Table 2, which gives the average results of tests upon pieces 2 inches square, with a span of 28 inches. It will be noted that the strength of these woods varies much the same as the weights given in Table 1 (page 15). There is a very general rule that light wood is weak and heavy wood strong, or that strength is proportional to weight. There are individual exceptions to this rule, but it holds true for most woods.

The softwoods are not generally so strong as the hardwoods; but some hardwoods are weaker than some softwoods; and some softwoods, notably longleaf pine, are stronger than many hardwoods. The ratio of bending strength to weight is about the same for hardwoods and softwoods. Dividing the modulus of rupture by the specific gravity (ciphers being dropped) gives the results shown in Table 3.

It appears that, among the hardwoods, black locust is the strongest in proportion to its weight, and willow the weakest. Redwood is the strongest softwood in proportion to its weight. In fact, redwood appears to be the strongest in proportion to weight of any wood yet tested at the Forest Service Laboratory, with the exception of black locust.

TABLE 3

Ratio of Bending Strength to Weight of Various Woods

(Modulus of Rupture Divided by Specific Gravity)

SOFTWOODS

Redwood	200	Douglas Fir	151
Hemlock, Western	174	Spruce, Red	150
Fir, Amabilis	173	Pine, White	147
Fir, White	171	Pine, Norway	146
Cedar, Incense	168	Tamarack	146
Cedar, Western Red	164	Pine, Sugar	146
Spruce, White	163	Cedar, Northern White	146
Pine, Longleaf	163	Pine, Table Mountain	146
Hemlock, Eastern	162	Fir, Alpine	143
Pine, Shortleaf	161	Hemlock, Black	143
Fir, Grand	160	Pine, Lodgepole	139
Cypress	158	Pine, Western Yellow	137
Larch, Western	158	Spruce, Englemann	135

Average Ratio of Bending Strength to Weight.. 155

HARDWOODS

Locust, Black	204	Ash, Pumpkin	155
Oak, Tanbark	191	Tupelo	154
Ash, Green	189	Oak, Swamp White	154
Ash, Blue	182	Gum, Red	150
Osage Orange	180	Butternut	149
Ash, White	179	Witch Hazel	148
Hickory, Pignut	179	Buckeye, Yellow	146
Hickory, Mockernut	178	Oak, Yellow	145
Locust, Honey	177	Birch, Sweet	145
Hickory, Shagbark	173	Basswood	143
Cherry, Black	171	Cherry, Red	140
Hickory, Water	170	Sycamore	140
Cucumber	169	Oak, Red	140
Hickory, Big Shellbark	167	Dogwood	137
Aspen, Largetooth	167	Laurel, Mountain	136
Hickory, Bitternut	166	Oak, White	136
Elm, Slippery	164	Maple, Silver	132
Elm, White	162	Sumac	130
Hickory, Nutmeg	162	Hackberry	129
Maple, Hard	162	Ash, Black	128
Elm, Rock	162	Oak, Post	125
Maple, Red	161	Oak, Bur	124
Beech	156	Willow, Black	101
Birch, Yellow	156		

Average Ratio of Bending Strength to Weight.. 156

TABLE 4

Crushing Strength of Various Woods

(Pounds per Square Inch; Pressure Applied Parallel to Grain)

SOFTWOODS

Spruce, White	1,940	Fir, Grand	3,030
Spruce, Englemann	1,980	Cedar, Incense	3,030
Cedar, Northern White	1,990	Fir, Amabilis	3,040
Fir, Alpine	2,060	Pine, Table Mountain	3,070
Pine, Western Yellow	2,400	Pine, Norway	3,080
Pine, Lodgepole	2,460	Hemlock, Eastern	3,270
Pine, Sugar	2,600	Hemlock, Western	3,390
Cedar, Western Red	2,630	Tamarack	3,480
Pine, White	2,720	Pine, Shortleaf	3,570
Spruce, Red	2,760	Larch, Western	3,700
Fir, White	2,800	Cypress	3,960
Hemlock, Black	2,890	Redwood	3,990
Douglas Fir	2,920	Pine, Longleaf	4,280

Average Crushing Strength............ 2,960

HARDWOODS

Willow, Black	1,320	Oak, White	3,510
Buckeye, Yellow	2,050	Cherry, Black	3,540
Basswood	2,140	Tupelo	3,550
Cherry, Red	2,170	Birch, Sweet	3,560
Ash, Black	2,300	Dogwood	3,640
Butternut	2,410	Elm, Rock	3,740
Maple, Silver	2,490	Maple, Hard	3,850
Hackberry	2,520	Hickory, Big Shellbark	3,890
Sumac	2,680	Hickory, Nutmeg	3,980
Gum, Red	2,690	Ash, Blue	4,180
Aspen, Largetooth	2,720	Ash, White	4,300
Sycamore	2,790	Laurel, Mountain	4,310
Elm, White	2,810	Oak, Swamp White	4,360
Cucumber	3,140	Ash, Green	4,360
Elm, Slippery	3,180	Hickory, Bitternut	4,570
Beech	3,280	Hickory, Shagbark	4,600
Oak, Bur	3,280	Hickory, Water	4,660
Oak, Post	3,330	Hickory, Mockernut	4,720
Ash, Pumpkin	3,360	Hickory, Pignut	4,820
Oak, Red	3,370	Oak, Tanbark	4,840
Oak, Yellow	3,390	Locust, Honey	4,970
Maple, Red	3,390	Osage Orange	5,810
Witch Hazel	3,400	Locust, Black	6,800
Birch, Yellow	3,460		

Average Crushing Strength............ 3,580

As with the other tables in this chapter, these results are to be taken only in a broad sense.

Crushing Strength. The resistance which a short post or a column offers to a weight placed on top is called its end-crushing strength, or strength in compression parallel to the grain. The crushing strength is expressed in terms of the weight required to crush a stick 1 inch square in cross-section, or in pounds per square inch.

The crushing strength of green wood of the principal species is approximately as indicated in Table 4.

Tensile Strength. Tensile strength is the opposite of crushing strength, or the force required to pull a substance apart. The tensile strength of wood parallel to the grain is from two to four times as great as the corresponding crushing strength, and considerably greater for hardwoods than for softwoods. When placed under compression, the fibers of wood tend to buckle or bend, and thus give way; but they offer great resistance to a force which tends to pull them apart.

Although the tensile strength of wood is many times referred to, in popular statements, as being a most important property, it is really not so necessary to determine, for most uses, as the resistance to bending and crushing. For all ordinary purposes, the tensile strength of wood is greater than stress of this sort to which it will be subjected, and hence no detailed discussion of the topic is necessary.

TABLE 5

Shearing Strength of Various Woods

Pounds per Square Inch

SOFTWOODS			
Fir, Amabilis	578	Pine, Table Mountain	712
Spruce, Englemann	592	Spruce, Eastern	721
Fir, Alpine	614	Fir, White	732
Cedar, Northern White	616	Fir, Grand	735
Cedar, Incense	638	Pine, Norway	776
Pine, White	644	Cypress	818
Pine, Western Yellow	684	Douglas Fir	856
Cedar, Western Red	698	Tamarack	863
Pine, Sugar	708	Hemlock, Eastern	876
Pine, Shortleaf	708	Pine, Longleaf	1,006
Pine, Lodgepole	712		
Average Shearing Strength	730		
HARDWOODS			
Willow	562	Ash, Pumpkin	1,214
Basswood	607	Birch, Sweet	1,220
Buckeye, Yellow	662	Oak, Yellow	1,237
Cherry, Red	678	Hickory, Bitternut	1,237
Butternut	756	Oak, White	1,251
Aspen	813	Elm, Rock	1,270
Ash, Black	860	Hickory, Mockernut	1,276
Elm, White	873	Oak, Swamp White	1,296
Cucumber	991	Oak, Post	1,299
Sycamore	1,001	Ash, Green	1,318
Tupelo	1,031	Hickory, Pignut	1,348
Hickory, Nutmeg	1,032	Oak, Bur	1,354
Maple, Silver	1,053	Maple, Sugar	1,380
Hackberry	1,093	Ash, White	1,380
Birch, Yellow	1,115	Hickory, Shagbark	1,298
Witch Hazel	1,118	Oak, Tanbark	1,414
Cherry, Black	1,127	Hickory, Water	1,440
Oak, Red	1,146	Dogwood	1,516
Elm, Slippery	1,148	Ash, Blue	1,544
Maple, Red	1,157	Laurel, Mountain	1,669
Hickory, Big Shellbark	1,187	Locust, Black	1,755
Beech	1,210	Locust, Honey	1,990
Average Shearing Strength	1,180		

Shearing Strength. The resistance which wood offers to a force which tends to make the fibers slip on one another, is called "shearing strength," and for many uses it is important that the shearing strength parallel to the grain be determined. This will be discussed later in the chapter on Paving Blocks. At this point it is necessary only to insert the tables which show the comparative shearing strength of the various species of wood, as determined by tests upon small pieces. The results, shown in Table 5, are given in pounds per square inch.

STIFFNESS

Stiffness is the resistance which a stick offers to a force that tends to change its shape. The stiffness of a stick of wood varies directly with the cube of its thickness, and inversely with the cube of its length. In other words, doubling the length of a stick makes it only one-eighth as stiff as previously; doubling the thickness makes it eight times as stiff as before.

Timber testing engineers express the stiffness of wood by what is called the "modulus of elasticity," which is stated in 1,000 pounds per square inch. The modulus of elasticity for the principal woods tested in a green condition is as indicated in Table 6.

The softwoods are nearly as stiff as the hardwoods, and, in comparison with their weights, much stiffer than the hardwoods. For example, Western red cedar, with a specific gravity

TABLE 6

Modulus of Elasticity of Various Woods

(Wood Tested in Green Condition; Modulus Given in Thousands of Pounds per Square Inch)

SOFTWOODS

Cedar, Northern White	643	Fir, White	1,131
Cedar, Incense	754	Spruce, Red	1,179
Spruce, Englemann	832	Tamarack	1,236
Fir, Alpine	861	Douglas Fir	1,242
Cedar, Western Red	886	Larch, Western	1,310
Hemlock, Black	936	Fir, Grand	1,311
Pine, Sugar	966	Fir, Amabilis	1,323
Spruce, White	968	Pine, Table Mountain	1,329
Pine, Western Yellow	977	Cypress	1,378
Pine, Lodgepole	993	Pine, Norway	1,384
Redwood	1,062	Pine, Shortleaf	1,395
Pine, White	1,073	Hemlock, Western	1,428
Hemlock, Eastern	1,123	Pine, Longleaf	1,662

Average Modulus of Elasticity.......... 1,130

HARDWOODS

Willow, Black	489	Beech	1,242
Sumac	809	Elm, Slippery	1,264
Oak, Bur	877	Hickory, Nutmeg	1,289
Oak, Post	913	Cherry, Black	1,308
Laurel, Mountain	924	Osage Orange	1,329
Maple, Silver	943	Hickory, Big Shellbark	1,330
Sycamore	964	Oak, Red	1,330
Butternut	969	Hickory, Bitternut	1,399
Buckeye, Yellow	981	Maple, Red	1,420
Basswood	995	Ash, White	1,457
Ash, Black	1,033	Maple, Hard	1,474
Hackberry	1,040	Ash, Green	1,480
Elm, White	1,040	Birch, Sweet	1,490
Cherry, Red	1,042	Hickory, Shagbark	1,532
Ash, Pumpkin	1,043	Birch, Yellow	1,543
Tupelo	1,045	Hickory, Water	1,563
Witch Hazel	1,112	Cucumber	1,565
Gum, Red	1,138	Oak, Swamp White	1,593
Oak, Yellow	1,170	Hickory, Pignut	1,648
Dogwood	1,175	Hickory, Mockernut	1,672
Aspen, Largetooth	1,185	Oak, Tanbark	1,678
Oak, White	1,214	Locust, Honey	1,732
Elm, Rock	1,222	Locust, Black	1,849
Ash, Blue	1,241		

Average Modulus of Elasticity.......... 1,250

of only .29, has a modulus of elasticity of 886,000 pounds per square inch; while bur oak, which is twice as heavy, is not quite so stiff as western red cedar. A study of the tables affords many interesting comparisons of this sort.

TOUGHNESS

Toughness is the reverse of stiffness, or the ability to bend without breaking. Toughness is one of the most useful properties of wood, and is especially desirable in handles, spokes, and various other articles.

The toughness of wood is not exactly determined by any single mechanical test. Perhaps it is best indicated by two tests which the engineers designate as the "work to maximum load," and "resistance to impact." The work to maximum load is expressed in inch-pounds per cubic inch; and the resistance to impact, in the height in inches necessary to drop a 50-pound hammer to cause complete breakage of the stick tested. The results of tests of this character are given in Table 7.

As a class, the hardwoods are nearly three times as tough as the softwoods, although, as in previous tests, there is an overlapping of the two groups. Alpine fir is the least tough of the softwoods, and longleaf pine the toughest, the latter being tougher than a number of hardwoods. Basswood and buckeye have the least toughness among the hardwoods; and hickory and osage orange are the toughest, the range being very wide.

TABLE 7

Toughness Tests of Various Woods

Work to Maximum Load

(Inch-pounds per Cubic Inch)

SOFTWOODS

Fir, Alpine	4.4	Pine, Norway	5.8
Cedar, Western Red	4.5	Pine, White	5.9
Spruce, Englemann	4.9	Spruce, Red	6.1
Pine, Sugar	5.0	Fir, Grand	6.2
Cypress	5.1	Spruce, White	6.6
Pine, Table Mountain	5.1	Douglas Fir	6.6
Pine, Western Yellow	5.1	Hemlock, Eastern	6.7
Pine, Lodgepole	5.2	Tamarack	7.2
Fir, White	5.2	Pine, Longleaf	8.1
Cedar, Northern White	5.7		

Average Work to Maximum Load........ 5.7

HARDWOODS

Basswood	5.3	Willow	12.9
Buckeye	5.4	Ash, Green	13.0
Aspen, Largetooth	6.1	Elm, Slippery	13.9
Cherry, Red	6.2	Oak, Swamp White	14.5
Sycamore	7.1	Ash, Blue	14.7
Tupelo	7.8	Locust, Black	15.4
Butternut	8.1	Birch, Sweet	15.6
Oak, Post	9.1	Ash, White	15.6
Ash, Pumpkin	9.4	Hackberry	16.5
Cucumber	10.0	Birch, Yellow	16.6
Maple, Red	10.6	Locust, Honey	17.3
Oak, Bur	10.7	Hickory, Water	18.8
Sumac	10.8	Elm, Rock	19.4
Maple, Silver	11.0	Witch Hazel	19.5
Elm, White	11.3	Hickory, Bitternut	20.0
Oak, Red	11.3	Hickory, Shagbark	20.2
Oak, White	11.4	Dogwood	21.0
Maple, Sugar	12.0	Hickory, Nutmeg	22.8
Ash, Black	12.2	Hickory, Mockernut	24.8
Oak, Yellow	12.4	Hickory, Pignut	29.5
Laurel, Mountain	12.5	Hickory, Big Shellbark	30.2
Beech	12.5	Osage Orange	37.9
Cherry, Black	12.8		

Average Work to Maximum Load........ 14.6

TABLE 7—(Concluded)

RESISTANCE TO IMPACT

(Height in inches at which drop of a 50-lb. hammer caused breakage of test piece)

SOFTWOODS

Fir, Alpine	9	Pine, Western Yellow	19
Pine, Table Mountain	10	Hemlock, Eastern	20
Spruce, Englemann	14	Douglas Fir	20
Cedar, Northern White	15	Cypress	23
Cedar, Western Red	16	Fir, Grand	25
Pine, Lodgepole	16	Tamarack	28
Pine, Sugar	17	Pine, Norway	28
Fir, White	18	Pine, Longleaf	35
Pine, White	18		

Average Resistance to Impact............ 19

HARDWOODS

Basswood	16	Oak, White	40
Buckeye, Yellow	18	Witch Hazel	40
Aspen	18	Oak, Red	40
Cherry, Red	22	Ash, Blue	43
Butternut	23	Birch, Sweet	44
Sycamore	24	Elm, Slippery	44
Tupelo	25	Locust, Black	44
Maple, Red	29	Oak, Bur	44
Maple, Silver	29	Willow	44
Cucumber	30	Elm, Rock	48
Ash, Pumpkin	31	Oak, Swamp White	50
Ash, Black	32	Hackberry	53
Laurel, Mountain	32	Hickory, Nutmeg	54
Cherry, Black	33	Hickory, Water	56
Elm, White	34	Locust, Honey	56
Maple, Sugar	36	Dogwood	58
Ash, Green	37	Hickory, Bitternut	66
Ash, White	37	Hickory, Shagbark	71
Oak, Post	38	Hickory, Mockernut	82
Oak, Yellow	39	Hickory, Pignut	91
Beech	40	Hickory, Big Shellbark	105
Birch, Yellow	40	Osage Orange	120

Average Resistance to Impact............ 45

HARDNESS

Hardness is a most important property of wood, since resistance to wear is necessary for a large number of purposes. In the Forest Service tests, hardness is determined by the weight required to force a steel ball .444 of an inch in diameter one-half its diameter into the wood. The tests upon green wood give the results shown in Table 8, the species being arranged from the softest to the hardest as expressed by the pressure in pounds necessary to make the required indentation.

The hardwoods as a class average from two to three times as hard as the softwoods. The hardest softwood, longleaf pine, is harder than basswood, buckeye, willow, butternut, and red cherry; but it is only about one-fourth as hard as osage orange, the hardest hardwood in the list. Their softness and ease of working make the softwoods as valuable for many purposes as are the hardwoods for other purposes.

EFFECT OF MOISTURE

The comparative properties of the various species of wood as indicated in the foregoing tables (Tables 2-8) are based upon tests of green timber, which give decidedly different results from tests upon dry timber.

Water occurs in wood in two forms: First, the water which fills the spaces between the cells in green wood; and second, that which saturates the walls of the cells. Often half the

TABLE 8

Hardness of Various Woods

(Pressure in pounds required to indent specimen to depth of one-half diameter of a .444-inch diameter steel ball)

SOFTWOODS

Fir, Alpine	219	Pine, Norway	342
Spruce, Englemann	243	Spruce, Red	346
Cedar, Western Red	246	Cypress	354
Cedar, Northern White	266	Tamarack	375
Pine, White	296	Fir, Grand	375
Pine, Lodgepole	315	Hemlock, Eastern	406
Pine, Western Yellow	320	Douglas Fir	408
Pine, Sugar	324	Hemlock, Black	464
Fir, White	328	Pine, Longleaf	512
Pine, Table Mountain	333		

Average Hardness 340

HARDWOODS

Basswood	242	Beech	824
Buckeye, Yellow	286	Maple, Hard	882
Willow, Black	334	Elm, Rock	888
Aspen, Largetooth	366	Birch, Sweet	894
Butternut	386	Oak, Yellow	926
Cherry, Red	386	Ash, White	941
Elm, White	511	Witch Hazel	977
Cucumber	515	Oak, Red	982
Ash, Black	548	Ash, Green	1,007
Sycamore	580	Ash, Blue	1,028
Sumac	590	Oak, White	1,063
Maple, Silver	592	Oak, Post	1,074
Maple, Red	612	Oak, Bur	1,108
Elm, Slippery	653	Oak, Swamp White	1,158
Cherry, Black	664	Laurel, Mountain	1,299
Hackberry	677	Dogwood	1,408
Tupelo	700	Locust, Black	1,568
Birch, Yellow	745	Locust, Honey	1,846
Ash, Pumpkin	752	Osage Orange	2,037

Average Hardness 844

weight of green wood, and sometimes more, consists of water. The amount of water required to saturate the walls of the cells is from 25 to 30 per cent of the weight of the wood when absolutely dry. This is called the "fiber saturation point." The amount of water in wood above this point has no effect upon the strength of wood; but, of course, it makes the wood heavier. When wood is dried below the fiber saturation point, its mechanical properties change rapidly, and the extent to which they change depends upon the degree to which the water is removed from the cell walls. Seasoned wood is stronger, stiffer, and harder than green wood. On the other hand, it may not be so tough as green wood, since dry wood is more likely to break than to bend and subsequently regain its form. Small pieces of thoroughly seasoned wood may be twice as strong as pieces of the same wood in green condition. Owing to the checks which frequently develop in the seasoning of large timbers, it is not safe to count upon any such great increase in strength in them as occurs in the seasoning of small timbers. This question is further discussed in the chapter on Structural Timbers.

Tests of small, clear pieces of wood dried to a moisture content of 12 per cent give the results shown in Table 9.

A comparison of the specific gravity of these woods at 12 per cent moisture, with the specific gravity of "oven-dry" woods given in Table

1 (page 15), shows that the latter are much lighter. On the other hand, the strength at 12 per cent moisture is much greater than for green timber as given in Table 2 (page 17).

TABLE 9

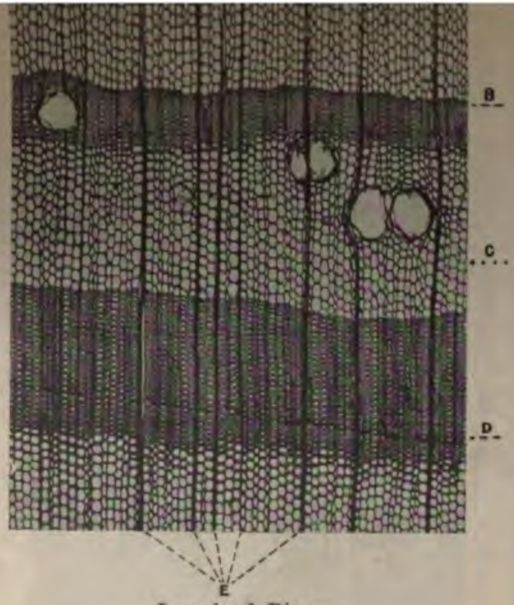
Weight and Strength of Wood with Moisture Content of 12 per Cent

Specific Gravity		Modulus of Rupture	
Cedar, Southern White	.37	Cedar, Southern White	6,300
Pine, White	.38	Douglas Fir	7,900
Cypress	.46	Cypress	7,900
Pine, Norway	.50	Pine, White	7,900
Douglas Fir	.51	Pine, Norway	9,100
Pine, Shortleaf	.51	Gum, Red	9,500
Gum, Red	.59	Pine, Shortleaf	10,100
Pine, Longleaf	.61	Elm, White	10,300
Ash, White	.62	Oak, Willow	10,400
Ash, Green	.62	Oak, Yellow	10,800
Pine, Loblolly	.63	Ash, White	10,800
Pine, Cuban	.63	Pine, Loblolly	11,300
Elm, White	.64	Oak, Overcup	11,300
Oak, Willow	.72	Oak, Red	11,400
Oak, Yellow	.72	Oak, Cow	11,500
Oak, Red	.73	Ash, Green	11,600
Oak, Spanish	.73	Oak, Spanish	12,000
Oak, Water	.73	Oak, Post	12,300
Hickory, Water	.73	Oak, Water	12,400
Oak, Texan	.73	Hickory, Nutmeg	12,500
Elm, Cedar	.74	Hickory, Water	12,500
Oak, Cow	.74	Pine, Longleaf	12,600
Oak, Overcup	.74	Oak, White	13,100
Hickory, Bitternut	.77	Oak, Texan	13,100
Pecan	.78	Elm, Cedar	13,500
Hickory, Nutmeg	.78	Pine, Cuban	13,600
Oak, Post	.80	Hickory, Bitternut	15,000
Oak, White	.80	Hickory, Mockernut	15,200
Hickory, Shagbark	.81	Pecan	15,300
Hickory, Mockernut	.85	Hickory, Shagbark	16,000
Hickory, Pignut	.89	Hickory, Pignut	18,700

SHRINKAGE OF WOOD

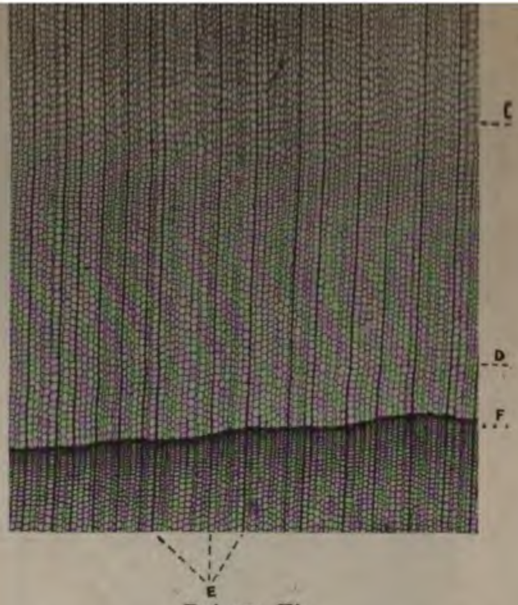
The amount which wood shrinks in passing from green to dry condition, is one of its most important properties. Shrinkage varies with the kind of timber, degree of seasoning, method of drying, and manner in which the piece is cut from the tree. Quarter-sawed timber shrinks less than slash-sawed; some methods of drying cause much greater shrinkage than others; and, as a class, the softwoods shrink less than the hardwoods. Moreover, shrinkage is chiefly across the grain; that is, a board loses breadth and thickness, but practically nothing in length, when it seasons.

Among softwoods, the cedars and white pines shrink the least. The spruces, firs, and softer pines shrink a medium amount; and longleaf pine and tamarack, the most. Among hardwoods, locust, osage orange, butternut, and black cherry shrink little; ash, elm, and maple, an average amount; and basswood, white oak, birch, and hickory, the most. Because of their more complex structure, the hardwoods also require greater care in seasoning than do the softwoods, to prevent warping and checking.



Longleaf Pine

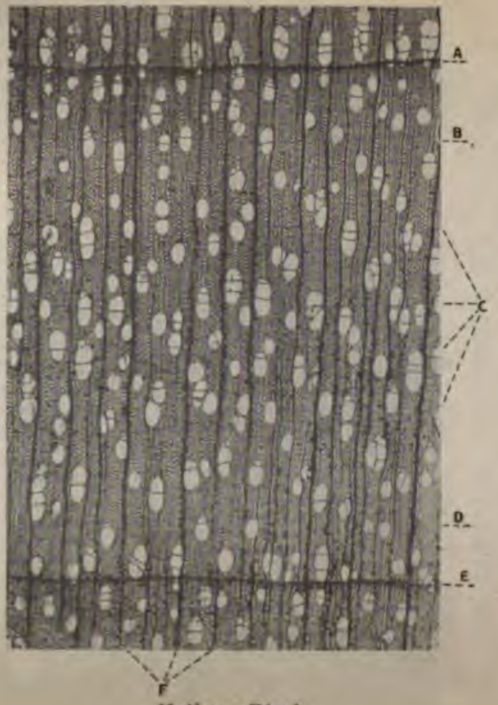
A non-porous wood. Large openings are resin ducts. B to A—One year's growth; B—Thick-walled summer wood cells; C—Thin-walled spring wood cells; D—Summer wood of previous year; E—Medullary rays.



Balsam Fir

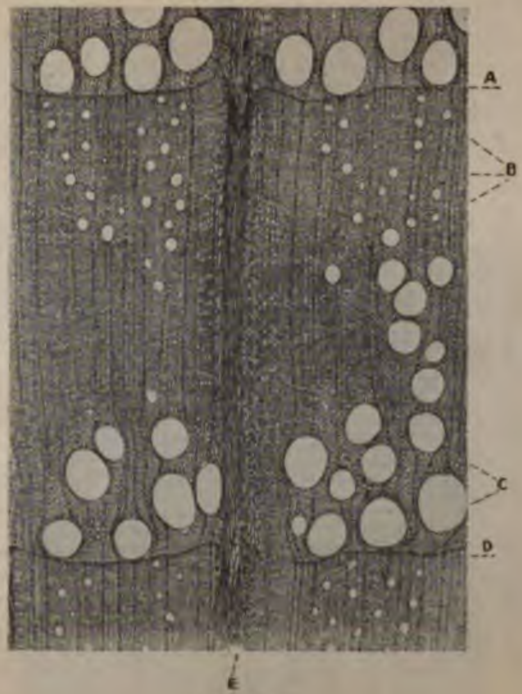
A non-porous wood. F to A—One year's growth; B—Summer wood; C—Cells thin-walled and almost uniform in size; D—Spring wood; E—Medullary rays.

Plate 4—Lumber and Its Uses



Yellow Birch

A diffuse-porous wood. E to A—One year's growth; B—Summer wood; C—Pores; D—Spring wood; F—Medullary rays.



Red Oak

A ring-porous wood. D to A—One year's growth; B—Small pores in summer wood; C—Large pores in spring wood; E—Medullary ray.

LUMBER GRADES

LUMBER is made a standard commercial product through its separation into grades according to quality and size. The grading of lumber is a commercial necessity for two reasons: First, to make it possible for the manufacturers to maintain a uniformity of production; and second, to adapt the product to the needs of many classes of customers.

PURPOSE OF GRADING

The aim of a grading system is excellently stated in one of the association rule books as being to make lumber of the same grade of approximately equal value when produced at different points, whether the logs from which the lumber is cut are large or small, coarse-knotted, fine-knotted, black-knotted, red-knotted, sound, or shaky. In other words, the purpose of the system is to enable each manufacturer to classify his product into grades of practically the same value to the customer as are the corresponding grades of lumber made by other manufacturers from the same kind of timber. The advantage to the customer in being thus enabled to obtain a standard product is too obvious to need any discussion.

In the early days of lumbering in the United States, the manufacturer paid little or no attention to grades. In fact, about all he did was

to separate his product into broad classes, known as "merchantable" and "cull" lumber. The former contained lumber of a character fit for general use; the latter, lumber of much poorer quality, which sold for a low price and was fit for little but temporary use or for the manufacture of boxes in the process of which the worst of the defects could be cut out. Under this system, or lack of system, the dealer purchased large stocks of lumber, and roughly separated them into classes adapted to the needs of his customers.

It was not until the later eighties that the manufacturers of lumber seriously undertook the establishment of a thorough-going system of grades for their products. By that time the annual output of lumber, and especially of white pine, had become so large that the adoption of uniform grades was really a necessity for both producer and consumer. And it was only through the organization of lumber manufacturers in a common territory and into an association, that standardization of product became possible. The first effective organization of this sort was that of the white pine manufacturers in the upper Mississippi Valley; and the plan which they adopted has been the essential basis upon which nearly all other organizations of lumber manufacturers have been built up.

The first thing the white pine manufacturers did was to agree upon the grades of lumber which should be recognized as standard, and

to take measures to make these standards known to both producers and consumers. This required that specifications be carefully drawn and published, and that experts be employed to apply them. The manufacturers therefore organized an inspection bureau composed of experienced lumber graders, whose duty it was to travel from mill to mill, instructing the manufacturers how to conform the product to standard grades. Moreover, these inspectors were sent to reinspect a shipment whenever the buyer complained that the manufacturers did not ship the grades named in the invoice. Work of this kind proved so beneficial that the example spread until, in every large manufacturing region in the United States, there is now an organization which determines the standard grades for each of the principal kinds of lumber, and whose authority in this respect is generally recognized. The development and general acceptance of these grading systems is one of the best examples we have of the growth of commercial usages which for all practical purposes are as binding as legal enactment.

THE BASIS FOR GRADES

Lumber is separated into grades on the basis of the defects which it contains; and the first step in the formulation of a grading system is to define the admissible defects. Defects usually recognized are: knots, knot-holes, shake, wane, rot, stain, etc. Poor manufacture is also

a defect; and grading rules generally require that lumber must be properly manufactured, with parallel edges and square ends.

In the determination of lumber grades, two general classes of usage are considered: First, those in which the lumber is used in its entirety; and second, those in which the lumber is cut to new dimensions in the process of re-working into other products. Into the first class falls the larger proportion of the softwood lumber used for general construction. Dimension, for example, is used for studding, joists, sills, rafters, etc.; and boards are used for siding, sheathing, roof-boards, partitions, and the like. In either case, the lumber is used in essentially the form and size in which it is first manufactured; and the grades provided for it require that the defects shall not be of such character or in such quantity as to impair the usefulness of the piece as a whole. In other words, a piece of dimension may contain knots, shake, pitch streaks, or decay; but these defects must not be so located or so numerous as to render the piece too weak to be used for studding, joists, and similar purposes.

The cutting grades of lumber find their largest use in factories where they are cut to smaller dimensions and re-worked into a multitude of articles, such as furniture, sash, doors, interior finish, packing boxes, etc. Many of the products of these factories contain only sound, clear lumber when finished; but, since

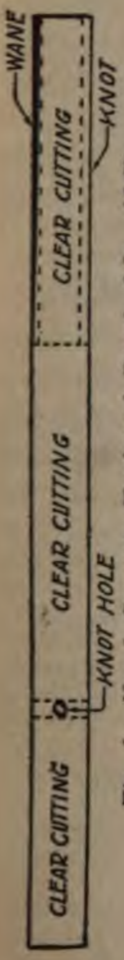


Fig. 1. No. 1 Common Hardwood Board, 8-In., 12-Ft. Cuts more than 66 2/3 per cent clear in three pieces

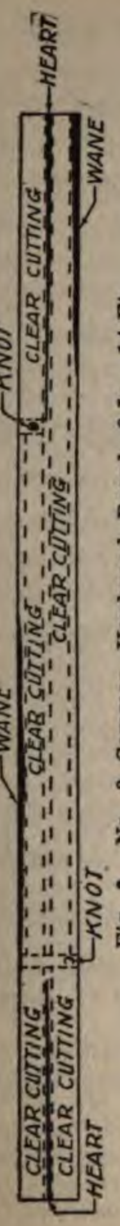


Fig. 2. No. 2 Common Hardwood Board, 8-In., 14-Ft. Cuts 50 per cent clear in five pieces

the lumber is cut into very different sizes from those in which it was originally manufactured, it is possible to cut out the portions which contain knots, rot, and other defects, and to obtain clear, sound pieces of the sizes needed for the finished articles. A common requirement in grades of this sort, therefore, is that a certain grade of lumber must contain a specified percentage of clear stock in sections of specified sizes. For example, the grade of No. 1 Shop Common in white pine must contain not less than 50 per cent nor more than 70 per cent of cuttings suitable for

use in the manufacture of doors, these cuttings to be of specified lengths and widths. Again, the rules of the National Hardwood Lumber Association require that the grade of No. 1 Common must contain clear stock in pieces 3 and 4 inches wide and 6 and 7 feet long; and that the larger boards of this grade must be of a character which will permit their being cut into a certain number of clear pieces equivalent in total size to two-thirds the area of the original board.

PRINCIPAL SYSTEMS OF GRADING

The principal associations of lumber manufacturers in the United States which have adopted standard grading rules for their products and for the woods which the members of each organization chiefly manufacture, are as follows:

California Sugar and White Pine Association, San Francisco, Cal.—Sugar pine, California white pine, Western yellow pine.

Georgia-Florida Sawmill Association, Jacksonville, Fla.—Yellow pine (chiefly longleaf, shortleaf, and Cuban pine).

Hardwood Manufacturers Association of the United States, Cincinnati, Ohio.—Ash, basswood, beech, buckeye, butternut, cherry, chestnut, cottonwood, elm, gum, hickory, maple, walnut, poplar, sycamore, tupelo.

Maple Flooring Manufacturers Association, Chicago, Ill.—Maple, beech, and birch flooring.

Michigan Hardwood Manufacturers Association, Cadillac, Mich.—Hemlock. Hardwood rules the same as the National Hardwood Lumber Association.

National Hardwood Lumber Association, Chicago, Ill.—Ash, basswood, beech, birch, buckeye, butternut, cherry, chestnut, cottonwood, sassafras, elm, gum, hickory, locust, magnolia, maple, oak, pecan, poplar, sycamore, walnut.

Northern Hemlock and Hardwood Manufacturers Association, Wausau, Wis.—Hemlock. Hardwood rules the same as the National Hardwood Lumber Association.

Northern Pine Manufacturers Association, Minneapolis, Minn.—White pine, Norway pine, spruce, tamarack.

North Carolina Pine Manufacturers Association, Norfolk, Va.—North Carolina pine (mostly loblolly; some shortleaf pine).

Oak Flooring Manufacturers Association, Detroit, Mich.—Oak flooring.

Redwood Manufacturers Association, San Francisco, Cal.—Redwood.

Southern Cypress Manufacturers Association, New Orleans, La.—Cypress, tupelo.

Spruce Manufacturers Association, New York, N. Y.—Eastern spruce.

West Coast Lumber Manufacturers Association, Tacoma, Wash.—Douglas fir, Western spruce, cedar, and hemlock.

Western Pine Manufacturers Association, Spokane, Wash.—Western pine, Idaho white pine, fir, and larch.

Yellow Pine Manufacturers Association, St. Louis, Mo.—Longleaf pine, shortleaf pine.

Copies of their complete grading rules are supplied by these associations upon application, free of charge, or at a nominal price. The associations are generally anxious to make their grades as widely known and used as possible.

Diversity of Grades

A few illustrations will suffice to show the extent to which the lumber manufacturers have gone in establishing grades suitable for a wide diversity of purposes. The rules of the Northern Pine Manufacturers Association provide for 7 grades of thick finishing lumber in thicknesses of 1¼ inches, 1½ inches, and 2 inches. There are also 9 grades of inch finishing lumber, 5 grades of siding and flooring, 3 grades of shiplap, 5 grades of shop lumber, 3 grades of factory select lumber, 6 grades of thick common lumber, 5 grades of common boards, 4 grades of

fencing, 3 grades of dimension, and 2 grades of lath. Under these rules the upper grades in the various classes are designated by letters as A, B, C, D, and the lower grades by numerals as No. 1, No. 2, No. 3, No. 4, and No. 5.

The rules for hardwoods adopted by the National Hardwood Lumber Association and the Hardwood Manufacturers Association provide in most cases for the following grades, beginning with the highest: Firsts and Seconds, No. 1 Common, No. 2 Common, and No. 3 Common. No. 4 Common is also provided for many woods. In addition to these general grades, there are a large number of special grades for the various hardwoods, covering box lumber, vehicle and wagon stock, furniture stock, flooring stock, quarter-sawed lumber, panel material, etc.

In the softwoods most largely used for general building purposes, there are usually three grades of common lumber generally known as No. 1, No. 2, and No. 3, or by terms of equivalent value. For example: No. 1 Dimension, Boards, etc., consist of sound, strong lumber suitable for first-class, all-round building purposes. The defects allowed in this lumber are not of a character which will materially impair the strength of the piece for the purpose intended. No. 2 stock contains more defects than No. 1, but is useful for the same general purposes in places where less strength is required. For example, studding of No. 2 Dimension is often as satisfactory as of No. 1 Dimension,

while No. 2 Boards make excellent sheathing, under-floors, roof-boards, etc. The No. 3 stock in Dimension and Boards is the lowest grade generally used for building purposes. It is mostly employed for very cheap, light, or temporary structures, and for these purposes affords a very economical building material.

Special grades in any item are put up by the manufacturers whenever ordered; but they cost more than regular grades, depending upon quality and handling charges.

Any large user of lumber will be well repaid if he familiarizes himself wtih the principal grades of the leading kinds of timber. By so doing he will be able to build better and more cheaply than if he specifies material without a full knowledge of its character and value.

STANDARD SIZES OF LUMBER

AS THERE were no well-defined grades in the early lumber manufacturing operations, so also was there little uniformity in the sizes to which the various classes of lumber were cut. In the early days, boards and larger material were shipped in the rough to planing mills at points of consumption, where they were dressed and worked to the desired sizes. With the development of the lumber industry and the greatly increased variety and efficiency of machinery, the manufacturers gradually began to work their products into forms suitable for final use. This process has gone on until to-day nearly every large sawmill which supplies car trade has a fully equipped planing mill in which lumber is dressed and worked into flooring, ceiling, shiplap, siding, partition, molding, etc., so that a practically complete bill of materials for a house can be shipped from the mill.

This advance in the development of lumber manufacturing makes the question of standard sizes as important as that of standard grades. In fact, the two naturally go hand in hand; and specifications for widths and thicknesses of dressed lumber are commonly a part of the grading rules of the associations of manufacturers.

There is some variation, according to species, in the lengths and widths of rough lumber made

in the sawmills. Since the softwoods are the more common structural material, and hence used in the entire piece, the dimensions vary somewhat from those of the hardwoods, of which the bulk are cut to new sizes in the process of re-manufacturing. The standard lengths of softwoods are commonly in multiples of 2 feet, beginning at 4 or 6 feet; and standard widths, in multiples of 2 inches, beginning at 4 inches. This is upon the theory that these dimensions are best adapted to the requirements of ordinary building operations for the placing of studding, joists, etc. In the hardwoods, standard lengths are usually in both odd and even feet, and standard widths in both odd and even inches. The most notable exception to these rules is in the manufacture of hardwood flooring, in which dimensions as small as 1 inch in width, 7 inches in length, and $\frac{3}{8}$ inch in thickness are produced.

While each association of lumber manufacturers has standards for working lumber, which are recognized within its territory, these standards frequently do not coincide with the standards of other associations. There is a much greater diversity in this respect than is desirable from the standpoint of the consumer; and doubtless in time, a greater uniformity will be brought about in standard sizes for all the more common kinds of lumber. The present standards for flooring, ceiling, shiplap, partition, boards, etc., for the principal commercial woods, are given in Table 10, in which the nominal dimen-

sion is named, together with the actual size of the finished product. The nominal dimension is the size which is figured in calculating the quantity of lumber sold, and is based upon rough stock; while the actual dimension indicates the actual width and thickness of the final product. For example, a piece of 1x4 Norway pine flooring is 13/16 inch thick, with a 3¼-inch face. That is, allowing for tongue and groove, each piece of flooring covers 3¼ inches of floor space. Since it is important that the user of lumber should know the exact sizes specified for the principal woods, the table is made as complete as the information at hand permits. In several cases where standard sizes have not been officially incorporated in association rules, the sizes made by the leading manufacturers are given.

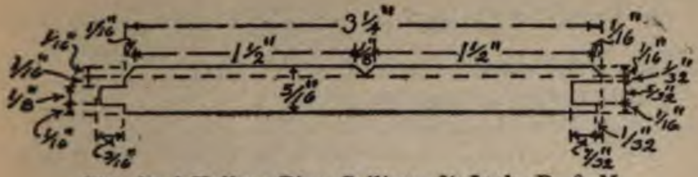
TABLE 10

Standard Sizes of Different Kinds of Lumber

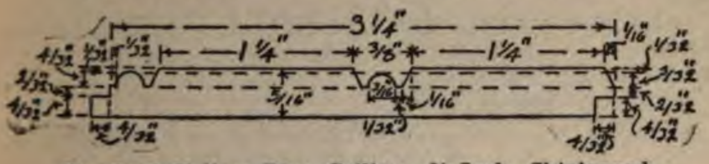
FLOORING (INCH)

F=Face. Width and thickness of tongue is ¼ inch, and dimensions of groove 1/32 inch greater.

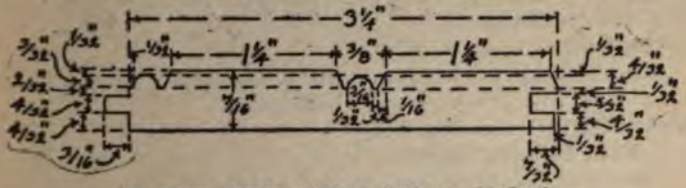
Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x4 is 13/16x3¼ F; 1x6 is 13/16x5¼ F.
North Carolina Pine (North Car. Pine Ass'n)	1x3 is 13/16x2½ F; 1x4 is 13/16x3½ F; 1x6 is 13/16x5½ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1x3 is 13/16x2½ F; 1x4 is 13/16x3¼ F; 1x6 is 13/16x5¼ F.
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	1x3 is 13/16x2¼ F; 1x4 is 13/16x3¼ F; 1x6 is 13/16x5¼ F.



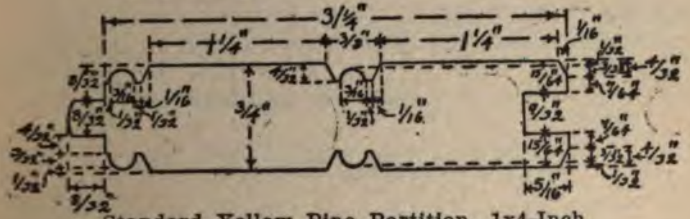
Standard Yellow Pine Ceiling, ⅜-Inch, D. & M.



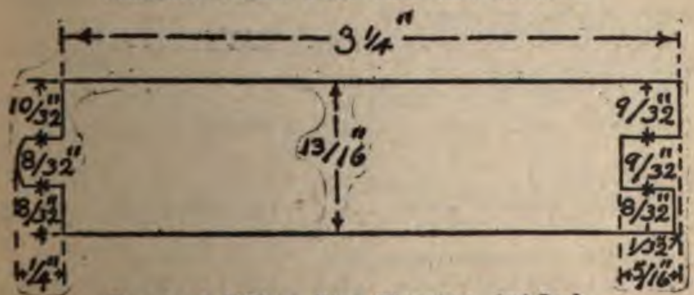
Standard Yellow Pine Ceiling, ⅜-Inch, Shiplapped



Standard Yellow Pine Ceiling, ½-Inch



Standard Yellow Pine Partition, 1x4-Inch



Standard Yellow Pine Flooring, 1x4-Inch

FIG. 3. STANDARD PATTERNS

Cypress and Tupelo
(So. Cypress Mfrs. Ass'n)...1x3 is 13/16x2¼ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5¼ F.

Douglas Fir, Western Hemlock, Cedar, and Spruce
(West Coast Lbr. Mfrs. Ass'n) ....1x3 is 13/16x2¼ F; 1x4 is 13/16 x3¼ F; 1x6 is 13/16x5¼.

Oak
(Oak Flooring Mfrs. Ass'n).13/16x1½, 2, or 2¼ F; ⅜x1½ or 2 F.

Maple, Beech, and Birch
(Maple Flooring Mfrs. Ass'n) ....Thicknesses — ⅜, ½, ⅝, 13/16, 1 1/16, 1 5/16, 1 11/16.
Faces—¾, 1, 1½, 2, 2¼, 3¼, 4, 4½.

Hemlock and Tamarack
(Nor. Hem. & Hdw. Mfrs. Ass'n) ....1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F.

Idaho White Pine, Western Pine, Fir, and Larch
(Western Pine Mfrs. Ass'n).1x4 is ¾x3⅛ F; 1x6 is ¾x5⅛ F; 1x8 is ¾x7⅛ F.

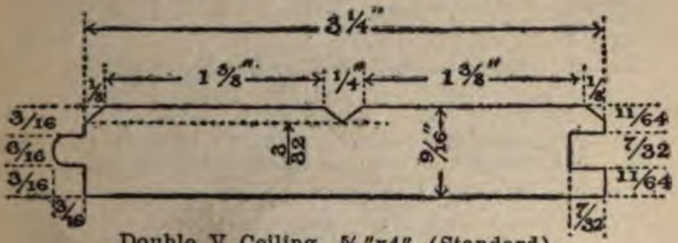
Gum and Yellow Poplar
(Nat. Hardwood Lbr. Ass'n).1x3 is 13/16x2¼; 1x4 is 13/16x 3¼ F; 1x5 is 13/16x4¼ F; 1x6 is 13/16x5¼ F.

CEILING (INCH)

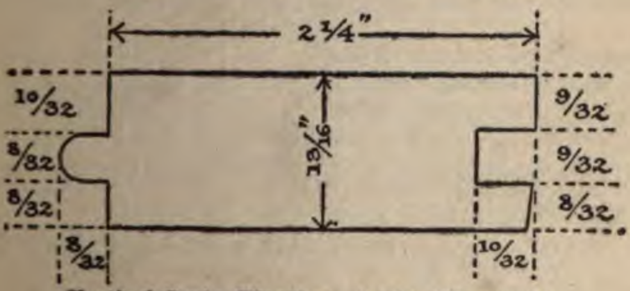
Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)....	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
North Carolina Pine (North Car. Pine Mfrs. Ass'n)	⅝x4 is ⅝x3⅛ F; ⅝x6 is ⅝x5⅛ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)...	¾x4 is 11/16x3¼ F; ¾x6 is 11/16 x5¼ F.
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)..	¾x4 is 11/16x3¼ F; ¾x6 is 11/16 x5¼ F.

"Novelty Rustic" Siding, 1"x6", No. 117 (Standard)
(West Coast Lumber Mfrs. Association)

Double-Beaded Ceiling or Partition
(West Coast Lumber Mfrs. Association)

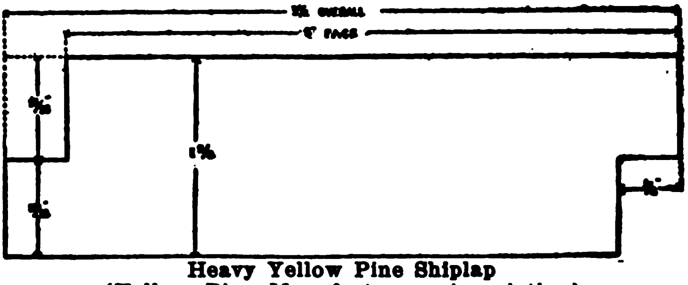


Double V Ceiling, ⅝"x4" (Standard)
(West Coast Lumber Mfrs. Association)

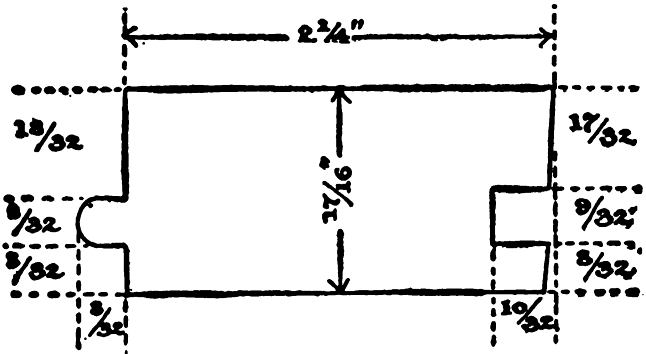


Vertical-Grain Flooring, 1"x3" (Standard)
(West Coast Lumber Mfrs. Association)

FIG. 4. STANDARD PATTERNS



Heavy Yellow Pine Shiplap
(Yellow Pine Manufacturers Association)



Vertical-Grain Flooring, 1¼"x3" (Standard)
(West Coast Lumber Mfrs. Association)

FIG. 5. STANDARD PATTERNS
CEILING (Continued)

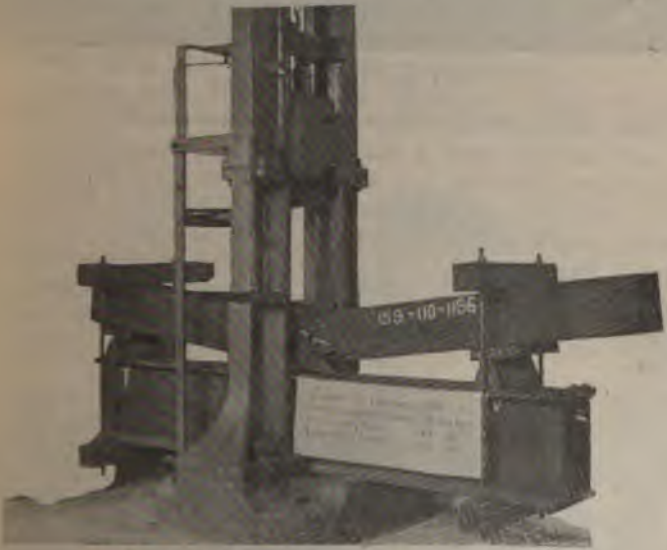
Cypress and Tupelo
(So. Cypress Mfrs. Ass'n)...¾x4 is 11/16x3¼ F; ¾x6 is 11/16 x5¼ F.

Douglas Fir, Western Hemlock, Cedar, and Spruce
(West Coast Lbr. Mfrs. Ass'n) ....1x4 is 11/16x3¼ F; 1x6 is 11/16 x5¼ F.

Hemlock and Tamarack
(Nor. Hem. & Hdw. Mfrs. Ass'n) ....1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F.

Northern Hardwoods
(Mich. Hdw. Mfrs. Ass'n)...1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F.

Bending Test of a Beam of Air-Dry Shortleaf Pine



Method of Making Impact Test of Bridge Tie

Torsion Tests of Soaked Hickory

FOREST SERVICE TESTS

Old Sawmills in Maine

These mills, located on tidewater, began operations in 1833

Photo by courtesy of Bolling Arthur Johnson

Modern Sawmill at Everett, Washington

A CONTRAST IN MILLING METHODS

Plate 7—Lumber and Its Uses

Idaho White Pine, Western Pine, Fir, and Larch
(West. Pine Mfrs. Ass'n)...1x4 is ¾x3⅛ F; 1x6 is ¾x5⅛ F; 1x8 is ¾x7⅛ F.

Redwood ....1x4 is 1 3/16x3¼ F; 1x6 is 13/16x5¼ F.

Gum
(Nat. Hdw. Lbr. Ass'n)....¾x3 is 11/16x2¼ F; ¾x4 is 11/16x3¼ F; ¾x5 is 11/16x5¼ F; ¾x6 is 11/16x5¼ F.

Yellow Poplar
(Nat. Hdw. Lbr. Ass'n)....Same as Flooring.

Tongues and grooves in inch Ceiling are usually of same dimensions as in inch Flooring. Ceiling is also often made in so-called thicknesses of ⅜, ½, and ⅝ inch, corresponding to dressed thicknesses of 5/16, 7/16, and 9/16 inch, respectively.

PARTITION (INCH)

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n.)	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
North Carolina Pine (Nor. Car. Pine Mfrs. Ass'n)	1x4 is 13/16x3½ F; 1x6 is 13/16 x5½ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	Same as above.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	Same as above.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lbr. Mfrs. Ass'n)	1x4 is 11/16x3¼ F; 1x6 is 11/16 x5⅛ F.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F.
Gum and Yellow Poplar (Nat. Hdw. Lbr. Ass'n)	Same as Flooring.

DROP SIDING (INCH)

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x4 is 25/32x3⅜ F; 1x6 is 25/32 x5¼ F; 1x8 is 25/32x7¼ F.

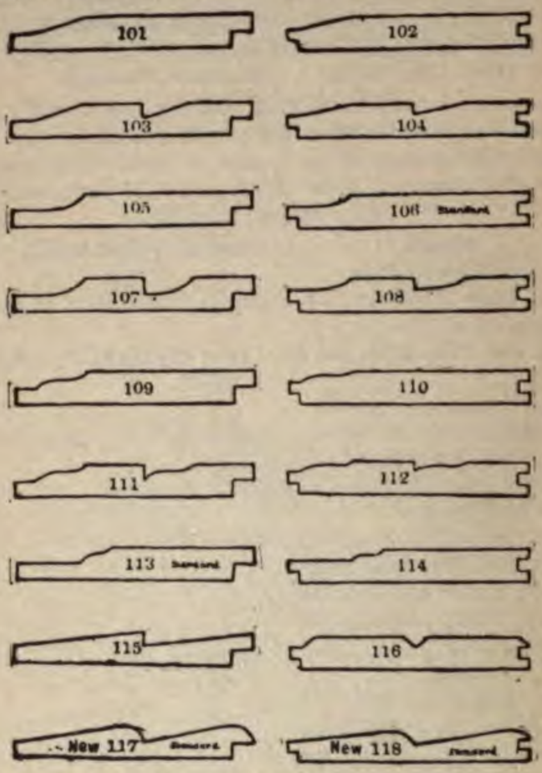
PATTERNS OF

Yellow Pine Drop Siding

Adopted at Memphis, Tenn., Jan. 16, 1901.
Revised at New Orleans, La., Jan. 25, 1905.

Worked Shiplap—$\frac{3}{4}$x$5\frac{1}{2}$ over all; allow $\frac{3}{8}$ inch for Lap.

Worked Tongue and Groove—$\frac{3}{4}$x$5\frac{1}{2}$ over all; $5\frac{1}{4}$ in Face



Orders for Stock Should Conform to above Numbers

FIG. 6

Note: With the exception of Nos. 117 and 118, the above patterns are similar in style to the "Universal" Patterns of Drop Siding and Ship-lap used by the manufacturers of Northern Pine and Hemlock.

North Carolina Pine
(Nor. Car. Pine Mfrs. Ass'n) . 1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F.

Longleaf Pine
(Ga.-Fla. Sawmill Ass'n) . . . Same as above.

Longleaf and Shortleaf Pine
(Yellow Pine Mfrs. Ass'n) . . Same as above.

Cypress and Tupelo
(So. Cypress Mfrs. Ass'n) . . . 1x4 is ¾x3¼ F; 1x6 is ¾x5¼ F; 1x8 is ¾x7¼ F.

Douglas Fir, Western Hemlock, Cedar and Spruce . . .
(West Coast Lbr. Mfrs. Ass'n) . . . . 1x4 is ¾x3¼ F; 1x6 is ¾x5⅜ F; 1x8 is ¾x7 F.

Hemlock and Tamarack
(Nor. Hem. & Hdw. Mfrs. Ass'n) . . . . 1x4 is 13/16x3¼ F; 1x6 is 13/16 x5¼ F; 1x8 is 13/16x7¼ F.

Northern Hardwoods
(Mich. Hdw. Mfrs. Ass'n) . . . 1x4 is 13/16x3¼ F; 1x6 is 13/16 x5⅜ F.

Idaho White Pine, Western Pine, Fir and Larch
(West. Pine Mfrs. Ass'n) . . . 1x4 is ¾x3⅜ F; 1x6 is ¾x5⅜ F; 1x8 is ¾x7⅛ F.

Redwood . . . . 1x4 is 1 3/16x3½ F; 1x6 is 13/16 x5½ F; 1x8 is 13/16x7½ F.

Yellow Poplar
(Nat. Hdw. Lbr. Ass'n) . . . . 1x4 is ¾x3¼ F; 1x5 is ¾x4¼ F; 1x6 is ¾x5¼ F.

FINISH S-1-S OR S-2-S

S-1-S = Surfaced one side; S-2-S = Surfaced two sides.

Woods	Thickness
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1" is 25/32"; 1¼" is 1⅛"; 1½" is 1⅜"; 2" is 1¾".
North Carolina Pine (Nor. Car. Pine Ass'n)	1" is 13/16"; 1¼" is 1 1/16"; 1½" is 1¼"; 2" is 1¾".
Longleaf Pine (Ga.-Fla. Sawmill Ass'n) . . .	1" is 13/16"; 1¼" is 1 1/16"; 1½" is 1 5/16"; 2" is 1¾".

Longleaf and Shortleaf Pine
(Yellow Pine Mfrs. Ass'n)..Same as above.
Cypress and Tupelo
(So. Cypress Mfrs. Ass'n)...1" is 13/16"; 1¼" is 1 1/16"; 1½" is 1 5/16"; 2" is 1¾".
Douglas Fir, Western Hemlock, Cedar and Spruce
(West Coast Lbr. Mfrs. Ass'n) ....1" is ¾"; 1¼" is 1 1/16"; 1½" is 1 5/16".
Hemlock and Tamarack
(Nor. Hem. & Hdw. Mfrs. Ass'n) ....1" is 13/16".
Idaho White Pine, Western Pine, Fir and Larch
(Western Pine Mfrs. Ass'n).1" is ¾".
Redwood ....1", 1¼", 1½", and 2" are 3/16" scant for S-1-S and ¼" scant for S-2-S.
Gum and Yellow Poplar
(Nat. Hdw. Lbr. Ass'n).....1" is 13/16".

FINISH S-1-E OR S-2-E

S-1-E = Surfaced one edge; S-2-E = Surfaced two edges.

Woods	Widths
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	4" is 3¼"; 6" is 5¼".
North Carolina Pine (Nor. Car. Pine Mfrs. Ass'n)	4" is 3¾"; 6" is 5¾"; 8" is 7¾"; 10" is 9¾"; 12" is 11¾".
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	4" is 3½"; 6" is 5½"; 8" is 7½"; 10" is 9½"; 12" is 11¼".
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	Same as above when S-4-S.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	4" is 3½"; 6" is 5½"; 8" is 7½"; 10" is 9½"; 12" is 11½".
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lbr. Mfrs. Ass'n)	4" is 3½"; 6" is 5½"; 8" is 7¼"; 10" is 9¼"; 12" is 11¼".

Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	4″ is 3¼″; 6″ is 5¼″.
Idaho White Pine, Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	½″ scant.
Redwood	½″ scant.
Gum and Yellow Poplar (Nat. Hdw. Lbr. Ass'n)	Same as Cypress and Tupelo.

SHIPLAP (INCH)

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	1x8 is 25/32x7⅛ F; 1x10 is 25/32x9⅛ F; 1x12 is 25/32x11⅛ F.
North Carolina Pine (Nor. Car. Pine Ass'n)	1x8 is 13/16x7¼ F; 1x10 is 13/16x9¼ F.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	1x8 is 25/32x7⅛ F; 1x10 is 25/32x9⅛ F.
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	1x8 is ¾x7⅛ F; 1x10 is ¾x9⅛ F; 1x12 is ¾x11⅛ F.
Cypress and Tupelo (So. Cypress Mfrs. Ass'n)	1x8 is 13/16x7 F; 1x10 is 13/16x9 F; 1x12 is 13/16x11 F.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lbr. Mfrs. Ass'n)	1x8 is ¾x7 F; 1x10 is ¾x9 F; 1x12 is ¾x11 F.
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	1x8 is 13/16x7¼ F; 1x10 is 13/16x9¼ F; 1x12 is 13/16x11¼ F.
Idaho White Pine, Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	1x8 is ¾x7 F; 1x10 is ¾x9 F; 1x12 is ¾x11 F.
Redwood	1x4 is 13/16x3½ F.

BOARDS (INCH)

Woods	Thickness
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 25/32".
North Carolina Pine (Nor. Car. Pine Mfrs. Ass'n)	S-1-S to ⅞", S-2-S to 13/16".
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	S-1-S or S-2-S to 13/16".
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	Same as above.
Cypress (So. Cypress Mfrs. Ass'n)	Same as above.
Douglas Fir, Western Hemlock, Cedar and Spruce (West Coast Lbr. Mfrs. Ass'n)	S-1-S or S-2-S to ⅞".
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n; Mich. Hdw. Mfrs. Ass'n)	S-1-S or S-2-S to 13/16".
Redwood	S-1-S to 13/16".
Sugar and California White Pine	S-2-S to ⅞".
Eastern Hardwoods (Nat. Hdw. Lbr. Ass'n; Hardwood Mfrs. Ass'n)	S-2-S to 13/16".

DIMENSION (2-INCH, S-1-S-1-E)

S-1-S-1-E = Surfaced one side and one edge.

Woods	Thickness and Width (Inches)
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½ and 11½.
North Carolina Pine (Nor. Car. Pine Mfrs. Ass'n)	2x4, 6, 8, 10, and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½, and 11½.
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	2x4, 6, 8, 10, and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½, and 11½.
Cypress (So. Cypress Mfrs. Ass'n)	Same as above.

Longleaf and Shortleaf Pine
(Yellow Pine Mfrs. Ass'n) . . 2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½ and 11½.

Douglas Fir and Western Hemlock
(West Coast Lbr. Mfrs. Ass'n) . . . . 2x4, 6, 8, 10 and 12, S-1-S-1-E to 1⅝x3⅝, 5⅝, 7½, 9½ and 11½.

Hemlock and Tamarack
(Nor. Hem. & Hdw. Mfrs. Ass'n) . . . . 2x4, 6, 8, 10 and 12, S-1-S-1-E to 1¾x3¾, 5¾, 7¾, 9¾ and 11¾.

Idaho White Pine, Western Pine, Fir and Larch
(West. Pine Mfrs. Ass'n) . . . 2x4, 6, 8, 10, 12 and 14, S-1-S-1-E to 1⅝x3⅝, 5½, 7½, 9½, 11½ and 13½.

Sugar and California White Pine . . . . S-2-S to 1⅞".

DIMENSION (3-INCH, S-1-S OR S-2-S)

Woods	Thickness
White and Norway Pine (Nor. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 2⅝".
North Carolina Pine (Nor. Car. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 2¾".
Longleaf Pine (Ga.-Fla. Sawmill Ass'n)	S-1-S or S-2-S to 2⅝".
Longleaf and Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	S-1-S to 2¾"; S-2-S to 2½".
Cypress (So. Cypress Mfrs. Ass'n)	S-1-S or S-2-S to 2¾".
Douglas Fir and Western Hemlock (West. Coast Lbr. Mfrs. Ass'n)	S-1-S or S-2-S to 2½".
Hemlock and Tamarack (Nor. Hem. & Hdw. Mfrs. Ass'n)	S-1-S or S-2-S to 2¾".
Western Pine, Fir and Larch (West. Pine Mfrs. Ass'n)	S-1-S or S-2-S to 2½".
Sugar and California White Pine	S-2-S to 2⅞".

HARDWOOD SIZES

The standard sizes adopted by the National Hardwood Lumber Association are as follows:

Standard Lengths

Standard lengths are 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, and 16 feet; but not over 15 per cent of odd lengths are admitted.

In the grade of Firsts and Seconds the lengths are 8 to 16 feet; but there must not be more than 20 per cent under 12 feet, and not to exceed 10 per cent of 8 and 9-feet lengths.

Standard Thicknesses

The standard thicknesses of hardwood lumber are: $\frac{1}{4}$, $\frac{3}{8}$, $\frac{1}{2}$, $\frac{5}{8}$, $\frac{3}{4}$, 1, $1\frac{1}{4}$, $1\frac{1}{2}$, $1\frac{3}{4}$, 2, $2\frac{1}{2}$, 3, $3\frac{1}{2}$, 4, $4\frac{1}{2}$, 5, $5\frac{1}{2}$, and 6 inches.

The standard thicknesses for surfaced lumber are as follows:

Rough		Surfaced	Rough		Surfaced
$\frac{3}{8}$″	S-2-S to	$\frac{3}{16}$″	$1\frac{3}{4}$″	S-2-S to	$1\frac{1}{2}$″
$\frac{1}{2}$″	S-2-S to	$\frac{5}{16}$″	2 ″	S-2-S to	$1\frac{3}{4}$″
$\frac{5}{8}$″	S-2-S to	$\frac{7}{16}$″	$2\frac{1}{2}$″	S-2-S to	$2\frac{1}{4}$″
$\frac{3}{4}$″	S-2-S to	$\frac{9}{16}$″	3 ″	S-2-S to	$2\frac{3}{4}$″
1 ″	S-2-S to	$\frac{13}{16}$″	$3\frac{1}{2}$″	S-2-S to	$3\frac{1}{4}$″
$1\frac{1}{4}$″	S-2-S to	$1\frac{3}{32}$″	4 ″	S-2-S to	$3\frac{3}{4}$″
$1\frac{1}{2}$″	S-2-S to	$1\frac{11}{32}$″			

Lumber surfaced one side only must be 1/16 inch full of the above thicknesses.

The standard sizes for hardwood lumber surfaced two sides adopted by the Hardwood Manufacturers Association are as above, except that these manufacturers work $\frac{3}{8}$-inch stock to 7/32 inch instead of 3/16 inch.

SHIPPING WEIGHTS

THE lumber manufacturer usually makes quotations upon the basis of delivery of the lumber to any point desired. To do this, it is necessary for him to know the weight of the product, in order to figure freight charges and add them to his f. o. b. mill price. For this reason, the grading rules of practically all lumber manufacturers' associations carry tables of estimated weights of lumber when dried to what is called "shipping condition." These weights are, of course, somewhat arbitrary; but they are based upon long experience, and are fair approximations of the weights of the commercial products which they represent. So far as they vary from actual weights, the estimated weights are likely to be a little higher than the exact weights. On the other hand, there is so much difference in the weight of wood depending upon the amount of seasoning, that not infrequently lumber is shipped when it is decidedly heavier than the estimated weights.

Softwoods

Estimated shipping weights of typical products of the principal softwoods in air-dry condition are indicated in Table 11.

TABLE 11

Shipping Weights of Softwoods

(Air-dried Except Where Otherwise Stated—Weights Indicated in Lbs. per 1,000 Feet, Board Measure)

	Timbers Rgh.	2" Dimension Rgh.	2" Dimension S-1-S-1-E	1" Boards Rgh.	1" Boards S-1-S or S-2-S	13/16" Flooring	13/16" Drop Siding	⅝" Drop Siding	⅝" Ceiling	4" Lath
White Pine and Hemlock	3,000	2,500	2,200	2,400	2,000	1,800	1,800	.....	1,500	500
Longleaf Pine (Yellow Pine Mfrs. Ass'n)	4,500	.....	2,700	.....	2,700	2,200	.....	1,900	1,500	550
Shortleaf Pine (Yellow Pine Mfrs. Ass'n)	4,200	.....	2,500	.....	2,500	2,000	.....	1,800	1,400	500
Longleaf Pine (Ga.-Fla. Saw-mill Ass'n)	.....	.....	3,500	.....	2,800	2,250	.....	2,300	.....	550
North Carolina Pine (Kiln-dried)	.....	3,500	.....	3,100	2,500	2,250	2,000	.....	1,700	...
Cypress	.....	3,200	2,600	3,000	2,400	2,200	2,200	.....	1,600	500
Douglas Fir	3,300	3,300	2,600	3,300	2,500	2,000	.....	2,000	1,400	500
Western Spruce	.....	.....	.....	.....	2,500	2,000	.....	.....	1,300	500
Western Hemlock	.....	.....	.....	.....	2,500	2,000	.....	2,000	.....	...
Idaho White Pine	.....	2,500	2,200	2,400	2,000	.....	.....	1,800	.....	500
Western Pine, Larch, Fir	.....	2,500	2,200	2,400	2,000	2,000	2,200	1,800	1,300	500
Sugar Pine	.....	2,650	2,300	2,500	2,200	.....	.....	.....	.....	450
Redwood	.....	2,600	2,200	2,400	2,000	.....	.....	.....	.....	...

Hardwoods

The estimated shipping weights for rough inch lumber of the common hardwoods in air-dry condition, are indicated in Table 12.

TABLE 12

Shipping Weights of Hardwoods

(Rough Inch Lumber—In Lbs. per 1,000 Feet, Board Measure)

Ash, Black ...	3,200	Gum, Red ...	3,300
Ash, White ...	3,500 to 3,800	Gum, Sap	3,000 to 3,100
Basswood	2,500 to 2,600	Hickory	4,500 to 5,000
Beech	4,000	Mahogany	3,500
Birch	4,000	Maple, Hard.	3,900 to 4,000
Buckeye	2,600	Maple, Soft...	3,000 to 3,300
Butternut	2,500 to 2,800	Oak	3,900 to 4,000
Cherry	3,800 to 4,000	Poplar, Yellow	2,800
Chestnut	2,800	Sycamore	3,000 to 3,200
Cottonwood ..	2,800	Tupelo	2,800
Elm, Rock ...	3,800 to 4,000	Walnut	4,000
Elm, Soft	3,000 to 3,300		

Kiln-Dried—

Oak Flooring, ⅜"x1½", 1,000 lbs.; ⅜"x2", 1,200 lbs.; 13/16"x 1½", 2,000 lbs.; 13/16"x2", 2,100 lbs.; 13/16"x2¼", 2,200 lbs.

Maple, Beech, and Birch Flooring, ⅜"x1½" or 2¼", 1,000 lbs.; 13/16"x1½" or 2¼", 2,100 lbs.

STRUCTURAL TIMBERS

TIMBERS are usually sawed from the heart of the log. It pays the lumber manufacturer better to cut the clear, outside portions of the log into higher classes of material than it does to cut them into timbers which bring a lower market price. For this reason, timbers may contain many or all of the defects common to the species from which they are cut. Since, however, timbers are large pieces of wood which are used as a whole, some small defects do not greatly reduce the strength, and larger defects of certain kinds may not be serious unless located at the points where the greatest strength is required.

The most serious defects in structural timbers are rot, knots, shake, and cross-grain. Sometimes a beam or timber may be so placed that these defects will not seriously interfere with strength, whereas in a reverse position, they would be very detrimental. For example, knots near the center or ends have practically no effect upon the strength of a beam.

The rate of growth is often thought to have much effect upon the strength of large timbers; but they are so likely to have defects of greater importance that the rate of growth alone cannot be depended upon to indicate the strength. In the same way, while seasoning small sticks

greatly increases their strength, it is not safe to assume that large timbers when seasoned are much stronger than when green. This is because checks which develop in seasoning are likely to offset the increase in strength due to the drying of the wood. For this reason, engineers do not ordinarily consider it advisable to figure upon a greater load for seasoned timbers than would be safe for timbers of the same size when green.

The Forest Service experiments in seasoning large timbers lead to these conclusions:

(1) In general, timber 8 by 16 inches in cross-section must season through two entire summers before it reaches a thoroughly air-dry condition.

(2) The weight of thoroughly air-seasoned timbers will vary appreciably during the year, due to the alternate evaporation and absorption of moisture. This change in moisture content is accompanied by a corresponding shrinking and swelling which tends to increase the size and number of checks formed through the seasoning process. These hygroscopic changes, however, do not seem to affect the interior of the timbers.

(3) If seasoning is started in the hot summer months, the loss of moisture is at first very rapid, even though the timber is protected from the sun and wind. The rapid loss in weight is associated with a marked shrinkage in the outer portion of the timber, which invariably induces checking. The loss in weight in a stringer 8 by 16 inches in cross-section and 16 feet long, in three months, varies from 40 to 60 pounds, the loss being proportional in a general way to the amount of sapwood the timber contains. Checking is less serious, however, when the timbers contain a considerable amount of sapwood than when they are practically all heartwood.

(4) The best results are obtained when the air-seasoning is started in the late fall or early winter months. At this time of the year, the air is usually moist enough to prevent rapid drying on the surface, and, in consequence, serious checking.

(5) The absence of shrinkage in redwood timbers is very noticeable, although redwood contains a large amount of moisture when cut. On account of its low-shrinkage factor, it can be seasoned without serious checking.

ASSOCIATION RULES FOR STRUCTURAL TIMBERS

Yellow Pine

The rules or specifications for structural timbers adopted by the Yellow Pine Manufacturers Association are:

No. 1 Common Timbers

Sizes. Common Timber shall be worked to the following: 4x4, 4x6, 6x6, ⅜-inch off side and edge. Surfaced 4 sides, ¼-inch off each side; 6x8 and larger, S-3-S or S-4-S, ¼-inch off each side surfaced.

Rough Timbers, 4x4 and larger, shall not be more than ¼-inch scant at any point when green, and be well manufactured, with not less than three square edges, and will admit sound knots that do not occupy more than one-third the cross-section of the piece or small defective knots.

Timbers 10x10 in size may have a 2-inch wane on one corner, measured on faces, or its equivalent on two or more corners one-third the length of the piece. Larger sizes may have proportionately greater defects.

Shakes extending not over one-eighth of the length of the piece are admissible, and seasoning checks shall not be considered a defect.

Dressed Timbers shall conform in grading to the specifications applying to rough timbers of same size.

Rough Timbers, if thicker than specified thickness for dry or green stock, may be dressed to such standard thickness, and when so dressed shall be considered as rough stock.

West Coast Timber

The grades for structural timbers adopted by the West Coast Lumber Manufacturers Association (applying chiefly to Douglas fir) are as follows:

Clears—Shall be sound lumber well sawed, one side and two edges free from knots and other defects impairing its use for the probable purpose intended. Will allow in dimensions larger than 6 by 10 inches pitch pockets when not extending through the piece; light-colored sap on corners not exceeding 3 inches on face and edge, knots 2 inches and less in diameter, according to size of piece, when on one face and one-half of each corresponding edge, leaving one face and upper half of each edge clear.

Selects—Shall be sound, strong lumber, well sawed. Will allow in sizes over 6 by 6 inch, knots, not to exceed 2 inches in diameter, varying according to the size of the piece; sap on corner not to exceed 2 inches on both face and edge; pitch pockets not to exceed 6 inches in length. Defects in all cases to be considered in connection with the size of the piece and its general quality.

Merchantable—This grade shall consist of sound, strong lumber, free from shakes, large, loose, or rotten knots, and defects that materially impair its strength, well manufactured, and suitable for good, substantial constructional purposes. Will allow slight variations in sawing, sound knots, pitch pockets, and sap on corners, one-third the width and one-half the thickness, or its equivalent. Defects in all cases to be considered in con-

nection with the size of the piece and its general quality. In timber 10 by 10 inches and over, sap shall not be considered a defect. Discolorations through exposure to elements, other than black sap, shall not be deemed a defect excluding lumber from this grade if otherwise conforming to merchantable grade.

Common—This grade shall consist of lumber having knots, sap, and other defects which exclude it from grading as merchantable, but of a quality suitable for rough kinds of work.

American Society for Testing Materials

The American Society for Testing Materials has been working for many years to establish commercial standards for all structural materials upon a scientific basis. The specifications which it has adopted for structural timber are as follows:

I. Definition of Structural Timber

By the term "Structural Timber" the Committee understands all such products of wood in which the strength of the timber is the controlling element in their selection and use. The following is a list of products which are recommended for consideration as structural timbers:

Trestle Timbers—Stringers, caps, posts, mud sills, bracing, bridge ties, guard rails.

Car Timbers—Car framing, including upper framing; car sills.

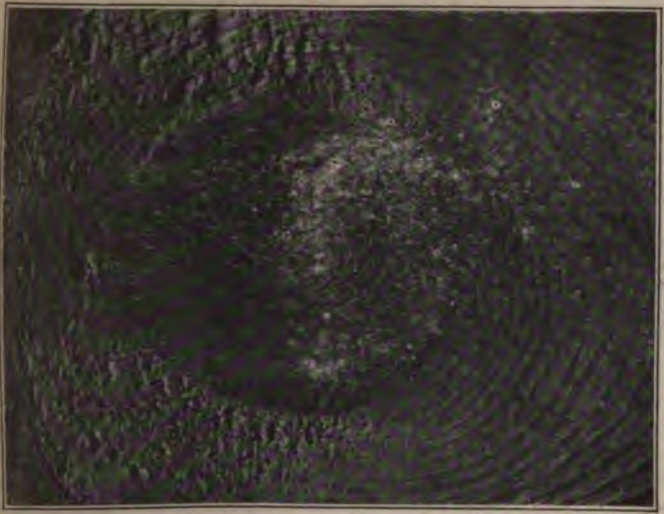
Framing for Buildings—Posts, mud sills, girders, framing, joists.

Ship Timbers—Ship timbers, ship decking.

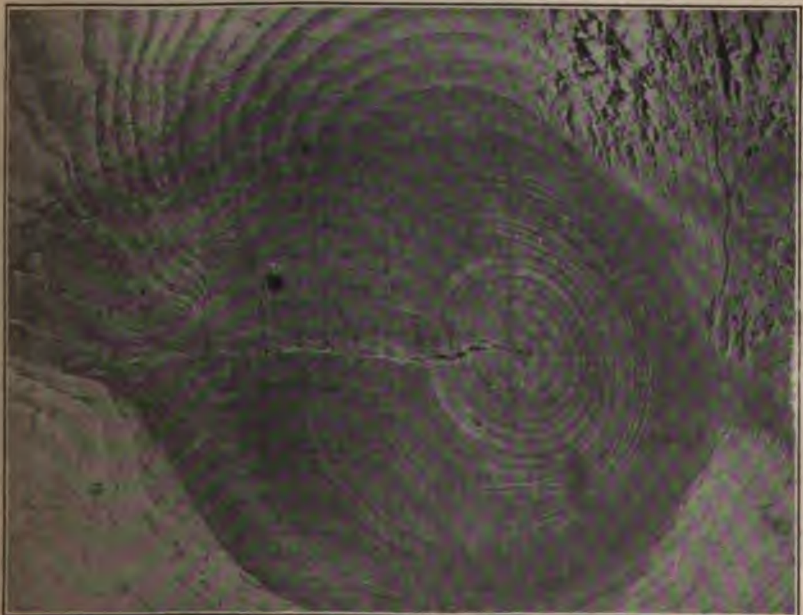
Cross-Arms for Poles.

II. Standard Defects

Measurements which refer to the diameter of knots or



Standard Knot

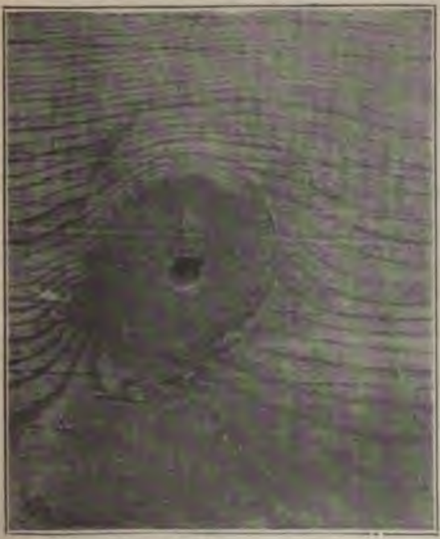


Large Knot

Plate 8—*Lumber and Its Uses*

Loose Knot

Encased Knot



Pith Knot

Rotten Knot

Plate 9—Lumber and Its Uses

holes should be considered as referring to the mean or average diameter.

1. **Sound Knot**—A sound knot is one which is solid across its face, and which is as hard as the wood surrounding it; it may be either red or black, and is so fixed by growth or position that it will retain its place in the piece.

2. **Loose Knot**—A loose knot is one not firmly held in place by growth or position.

3. **Pith Knot**—A pith knot is a sound knot with a pith hole not more than ¼ inch in diameter in the center.

4. **Encased Knot**—An encased knot is one which is surrounded wholly or in part by bark or pitch. Where the encasement is less than ⅛ of an inch in width on both sides, not exceeding one-half the circumference of the knot, it shall be considered a sound knot.

5. **Rotten Knot**—A rotten knot is one not as hard as the wood it is in.

6. **Pin Knot**—A pin knot is a sound knot not over ½ inch in diameter.

7. **Standard Knot**—A standard knot is a sound knot not over 1½ inches in diameter.

8. **Large Knot**—A large knot is a sound knot more than 1½ inches in diameter.

9. **Round Knot**—A round knot is one which is oval or circular in form.

10. **Spike Knot**—A spike knot is one sawn in a lengthwise direction; the mean or average width shall be considered in measuring these knots.

11. **Pitch Pockets**—Pitch pockets are openings between the grain of the wood containing more or less pitch or bark. These shall be classified as "small," "standard," and "large" pitch pockets.

(a) **Small Pitch Pocket.** A small pitch pocket is one not over ⅛ of an inch wide.

(b) **Standard Pitch Pocket.** A standard pitch pocket is one not over ⅜ of an inch wide or 3 inches in length.

(c) **Large Pitch Pocket.** A large pitch pocket is one over ⅜ of an inch wide or over 3 inches in length.

12. **Pitch Streak**—A pitch streak is a well-defined accumulation of pitch at one point in the piece. When not sufficient to develop a well-defined streak, or where the fiber between grains—that is, the coarse-grained fiber, usually termed "Spring wood"—is not saturated with pitch, it shall not be considered a defect.

13. **Wane**—Wane is bark, or the lack of wood from any cause, on edges of timbers.

14. **Shakes**—Shakes are splits or checks in timbers which usually cause a separation of the wood between annual rings.

15. **Rot, Dote, and Red Heart**—Any form of decay which may be evident either as a dark red discoloration not found in the sound wood, or the presence of white or red rotten spots, shall be considered as a defect.

16. **Ring Shake**—An opening between the annual rings.

17. **Through Shake**—A shake which extends between two faces of a timber.

III. Standard Names for Structural Timbers

1. **Southern Yellow Pine**—Under this heading, two classes of timber are used: (1) Longleaf Pine; (2) Shortleaf Pine.

It is understood that these two terms are descriptive of quality, rather than of botanical species. Thus, "Shortleaf Pine" would cover such species as are now known as North Carolina pine, loblolly pine, and shortleaf pine. "Longleaf Pine" is descriptive of quality; and if Cuban, shortleaf, or loblolly pine is grown under such conditions that it produces a large percentage of hard summer wood, so as to be equivalent to the wood produced by the true longleaf, it would be covered by the term "Longleaf Pine."

2. **Douglas Fir**—The term "Douglas Fir" to cover the timber known likewise as yellow fir, red fir, Western fir, Washington fir, Oregon or Puget Sound fir or pine, norwest and west coast fir.

3. **Norway Pine,** to cover what is known also as "Red Pine."

4. **Hemlock,** to cover Southern or Eastern hemlock—that is, hemlock from all States east of and including Minnesota.

5. **Western Hemlock,** to cover hemlock from the Pacific coast.

6. **Spruce,** to cover Eastern spruce—that is, the spruce timber coming from points east of Minnesota.

7. **Western Spruce,** to cover the spruce timber from the Pacific coast.

8. **White Pine,** to cover the timber which has hitherto been known as white pine, from Maine, Michigan, Wisconsin, and Minnesota.

9. **Idaho White Pine,** the variety of white pine from western Montana, northern Idaho, and eastern Washington.

10. **Western Pine,** to cover the timber sold as white pine coming from Arizona, California, New Mexico, Colorado, Oregon, and Washington. This is the timber sometimes known as "Western Yellow Pine," or "Ponderosa Pine," or "California White Pine," or "Western White Pine."

11. **Western Larch,** to cover the species of larch or tamarack from the Rocky Mountain and Pacific coast regions.

12. **Tamarack,** to cover the timber known as "Tamarack," or "Eastern Tamarack," from States east of and including Minnesota.

13. **Redwood,** to include the California wood usually known by that name.

IV. Standard Specifications for Bridge and Trestle Timbers

(To be applied to solid members and not to composite members)

GENERAL REQUIREMENTS

Except as noted, all timber shall be cut from sound trees and sawed standard size; close-grained and solid; free from defects such as injurious ring shakes and crooked grain, unsound knots, knots in groups, decay, large pitch pockets, or other defects that will materially impair its strength.

Standard Size of Sawed Timber—Rough timbers when sawed to standard size, shall mean that they shall not be over ¼ in. scant from actual size specified. For instance, a 12 in. x 12 in. shall measure not less than 11¾ in. x 11¾ in.

Standard Dressing of Sawed Timbers—Standard dressing means that not more than ¼ in. shall be allowed for dressing each surface. For instance, a 12 in. x 12 in. shall, after dressing four sides, not measure less than 11½ in. x 11½ in.

STRINGERS

No. 1. Longleaf Yellow Pine and Douglas Fir—Shall show not less than 80 per cent of heart on each of the four sides, measured across the sides anywhere in the length of the piece; loose knots, or knots greater than 1½ in. in diameter, will not be permitted at points within 4 inches of the edges of the piece.

No. 2. Longleaf Yellow Pine, Shortleaf Pine, Douglas Fir, and Western Hemlock—Shall be square edged, except it may have 1 in. wane on one corner. Knots must not exceed in their largest diameter ¼ the width of the face of the stick in which they occur. Ring shakes extending not over ⅛ of the length of the piece are admissible.

CAPS AND SILLS

No. 1. Longleaf Yellow Pine and Douglas Fir—Shall show 85 per cent heart on each of the four sides, meas-

ured across the sides anywhere in the length of the piece; to be free from knots over 2½ in. in diameter; knots must not be in groups.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir, and Western Hemlock—Shall be square-edged, except it may have 1 in. wane on one corner, or ½ in. wane on two corners. Knots must not exceed in their largest diameter ¼ the width of the face of the stick in which they occur. Ring shakes extending not over ⅛ the length of the piece are admissible.

POSTS

No. 1. Longleaf Yellow Pine and Douglas Fir—Shall show not less than 75 per cent heart, measured across the face anywhere on the length of the piece; to be free from knots over 2½ in. in diameter, and must not be in groups.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir, and Western Hemlock—Shall be square-edged, except it may have 1 in. wane on one corner, or ½ in. wane on two corners. Knots must not exceed, in their largest diameter, ¼ the width of the face of the stick in which they occur. Ring shakes shall not extend over ⅛ of the length of the piece.

LONGITUDINAL STRUTS OR GIRTS

No. 1. Longleaf Yellow Pine and Douglas Fir—Shall show one face all heart; the other face and two sides shall show not less than 85 per cent heart, measured across the face or side anywhere in the piece; to be free from knots 1½ in. in diameter and over.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir, and Western Hemlock—Shall be square-edged and sound; to be free from knots 1½ in. in diameter and over.

LONGITUDINAL X-BRACES, SASH BRACES, AND SWAY BRACES

No. 1. Longleaf Yellow Pine and Douglas Fir—Shall show not less than 80 per cent heart on two faces and

four square edges; to be free from knots over $1\frac{1}{2}$ in. in diameter.

No. 2. Longleaf and Shortleaf Yellow Pine, Douglas Fir, and Western Hemlock—Shall be square-edged and sound; to be free from knots $2\frac{1}{2}$ in. in diameter and over.

FOREST SERVICE RULES

As the result of tests upon structural timbers, the Forest Service proposes the following grades:

Grade 1—Timbers having a modulus of rupture over 4,000 pounds per square inch.

Grade 2—Serviceable timbers having a modulus of rupture under 4,000 pounds per square inch.

Culls—Timbers having visible defects which render them unfit for structural purposes.

The practical application of these grades is illustrated by the following definitions of terms and tentative rules for timbers, based upon a long series of tests:

DEFINITIONS

Shakes

A shake is a separation of one annual ring from another, in some cases only a few degrees in length, in others entirely separating two rings. It is thought that shakes are produced in the living tree by stresses caused by winds and changes of temperature. They are most common in woods that split easily. Shakes are difficult to detect in green timber, and usually do not become visible until the timber is at least partly seasoned. A

shake decreases the strength of timber in proportion as a plane tangent to it approaches parallelism with the neutral plane in the beam, since the more nearly parallel the two planes the smaller is the area resisting horizontal shear.

Checks

Checks are radial cracks or splits produced, almost without exception, by uneven shrinkage during seasoning. Occasionally, however, they are present in green timber.

Cross-Grains

Cross-grain may be divided into three general classes:

Diagonal Grain—In sawing lumber, if the plane of the saw is not approximately parallel to the axis of the log, the grain of the lumber cut is not parallel to the edges, and is termed diagonal.

Spiral Grain—In many trees the fibers composing each year's growth are ranged spirally instead of vertically. The greater the pitch of the spiral, the greater is the defect. Spiral grain usually cannot be detected from a casual inspection of the piece, since it does not show in the so-called visible grain of the wood, which in softwood lumber is nothing but a sectional view of the annual rings cut longitudinally. A careful inspection, however, of the medullary rays on the tangential or bastard section, will invariably reveal spiral grain, since the rays necessarily incline with the spiral direction of the fibers around the trunk, and therefore, in section, appear obliquely on the face of the timber. Spiral grain may readily be detected also by splitting a small piece radially.

Burls—Burls are local disturbances in the grain of timber, usually associated with knots or produced by the healing of wounds during the life of the tree.

Pitch Pockets

Pitch pockets are cavities between annual rings, usually filled with resin. They are rarely large enough to affect seriously the strength of structural timbers.

Knots

Knots are portions of branches which have been encased in the growing trunk of the tree. In judging their effect upon the strength of timber, it should be borne in mind that the axis of a knot always extends to the center or pith of the tree, and that the visible part of the knot is a section of a somewhat conical mass of wood, the apex of the cone being at the pith of the tree, and the knot, as a whole, more or less intertwined with the wood surrounding it. A spike knot is a longitudinal section of a whole knot; and a round or elliptical knot is a section, respectively at right angles or at some oblique angle, to the axis of the knot. Sound knots, as a rule, are stronger and harder than the wood fiber surrounding them. Their effect, therefore, upon the strength of the timber depends to a large extent upon the manner in which they are connected to the surrounding wood and upon the degree of stress to which the connecting fibers are subjected. If the knots disturb the grain so that it is decidedly oblique to the edges of the timber, the wood will be subjected to stresses in tension at right angles to the grain, the kind to which it offers the least resistance. In such cases early failure in cross-grain tension almost invariably results.

Class 1 Knots—Class 1 knots must be solid, firmly attached to the surrounding wood, and must cause no marked irregularity in the grain of the timber. Small spike knots will be included in this class.

Class 2 Knots—Class 2 knots must be solid, but are insecurely attached to the surrounding wood, or associated with burl or other irregularity in the grain.

Class 3 Knots—Class 3 knots are unsound knots; that is, they are softer than the surrounding wood.

Dimensions of Knots—The dimension of a knot on the narrow face of a timber will be the projection of the knot

on a line perpendicular to an edge of the timber. On the wide, or vertical, faces the smallest diameter of a knot is to be taken as its dimension.

Small Knots—Knots less than $1\frac{1}{2}$ inches in diameter.

Large Knots—Knots $1\frac{1}{2}$ inches or more in diameter.

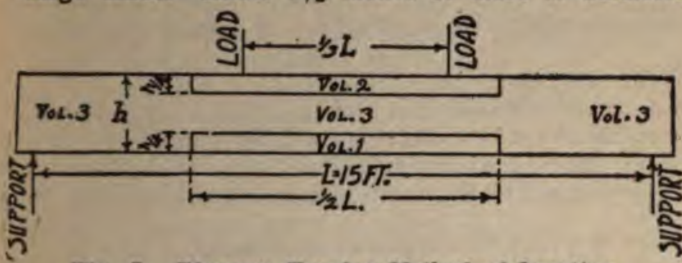


Fig. 7. Diagram Showing Method of Locating Defects in Stringers

Position of Defects—The position of defects is designated by means of the three volumes indicated in the diagram (Fig. 7).

Dense Wood

The term "dense wood" is used to define the quality of wood which is desirable in timbers subjected to stresses such as occur in frame structures. The term applies to the wood itself, irrespective of defects. Since dry weight, which is the most accurate index to the mechanical properties of wood, cannot be determined from a casual inspection of the timber, dense—or, in other words, comparatively heavy—wood will be defined as:

(1) Wood that shows more than eight rings per inch, or the rings of which contain more than 30 per cent summerwood.

(2) Wood which is resilient—that is, which, when struck with a hammer or similar blunt instrument, gives a sharp, clear sound, while the hammer shows a marked tendency to rebound and the wood to recover from the effects of the blow.

These properties are to be judged from an inspection of the cross-section of the timber.

TENTATIVE GRADING RULES

The following tentative rules are for the purpose of strength classification only, and do not take into account requirements of a general nature such as conformity to dimensions, proportion of sap, or other requirements made necessary by peculiarities of certain species.

Grade 1 Timbers

(a) Must contain only dense wood.

(b) Must not have Class 2 or large Class 1 knots in volume 1.

(c) Must not have large Class 2 knots in volume 2.

(d) The aggregate diameter of knots on any face within the center half of the length shall not exceed the width of the face.

(e) Must not have shakes or deep checks.

(f) Must not have diagonal grain with a slope greater than 1 inch in 20.

Grade 2 Timbers

(a) Must contain only dense wood.

(b) Must not have large Class 2 knots in volume 1.

(c) The aggregate diameter of knots on any face in the center half of the length shall not exceed two times the width of the face.

(d) Must not have shakes which extend along an annual ring a distance greater than the width of the piece.

Classification of Timbers

As the result of the application of the proposed grades to the species tested, the Forest Service classifies them in order of strength as follows:

Class 1 Timbers—To include Grade 1 timbers for longleaf pine, shortleaf pine, loblolly pine, and Douglas fir. Shortleaf pine and loblolly pine, however, generally contain quite a large proportion of sapwood, which is not nearly so durable as the heartwood. Therefore unless these species were treated with a preservative, they should be excluded from this class and put into Class 2.

Class 2 Timbers—To consist of Grade 2 longleaf pine, Grade 2 Douglas fir, Grade 1 western larch and hemlock, and Grade 1 tamarack.

Class 3 Timbers—To include Grade 1 redwood, Grade 1 Nor-

way pine, Grade 2 shortleaf pine, Grade 2 loblolly pine, Grade 2 tamarack, Grade 2 western hemlock.

This classification is based entirely upon the strength developed by the timbers tested, and does not take into consideration other properties which may be desirable for any particular use. For example, the durability of the different species is influenced greatly by the amount of sapwood which the timbers contain. Shortleaf pine, loblolly pine, Norway pine, and tamarack usually contain a considerable proportion of sapwood. All of the other species mentioned can be secured, as a rule, in dimension sizes practically free from sapwood. If, however, the timbers are to be given a preservative treatment, sapwood may be an advantage, since it readily absorbs creosote and other preservatives.

CONCLUSIONS

The tests of the Forest Service upon structural timbers lead to these conclusions:

(1) The mechanical properties of timber beams are dependent upon: a, The quality of the wood irrespective of defects; b, the character and location of defects.

(2) The mechanical properties of wood free from defects vary directly with its dry weight. The relative dry weight of the different pieces of wood of any species can be approximated by comparing the proportion of summerwood in each.

(3) The only defects which materially decrease the breaking strength of timber beams are the more serious ones, such as large knots and cross-grains occurring where fibers are subjected to comparatively high stresses.

(4) All the species tested seem to be subject to the same general laws regarding the relation of mechanical to physical properties.

SEASONING OF TIMBER

FRESHLY cut timber frequently contains half its weight of water, or, stated otherwise, it contains 100 per cent of water based upon the absolutely dry weight of the wood. A large proportion of this excess water must be removed before the timber is in shape to use, and the process by which it is removed is called "seasoning." Seasoning usually increases the strength, stiffness, and hardness of timber, greatly reduces its weight, and renders it less likely to shrink in subsequent usage. Timber is used green only when absolutely necessary, since, among other undesirable qualities, it is more likely to decay than is seasoned timber.

There are two general methods of seasoning timber—the natural and the artificial, or air-drying and kiln-drying. Air-dried timber may contain from 15 to 30 per cent of moisture, depending upon kind, size, climate, and other factors. Kiln-dried timber usually contains 5 to 10 per cent of moisture; while in what is called "oven-dry" or "bone-dry" wood, the moisture content is less than 1 per cent of the absolutely dry weight of the wood.

For ordinary structural timber, studding, sheathing, and the like, air-drying is sufficient. For the more refined uses of timber where it is

re-worked into flooring, finish, furniture, and other articles, thorough kiln-drying is necessary to reduce as much as possible the tendency to swell and shrink with atmospheric changes. Heavy material like vehicle stock may be air-dried for two or three years, and then kiln-dried slowly for a long time to obtain the necessary seasoning with the least checking and warping.

Thin boards of any kind of lumber exhibit more or less tendency to check and twist during seasoning processes. This tendency is greater in the hardwoods than in the softwoods, because of the much more complex structure of the hardwoods. Commercial practice has, however, made such rapid strides in the last few years that almost any kind of timber is now successfully seasoned by either natural or artificial means. For many years, cottonwood and gum were rejected by sawmill operators, because of the general belief that they could not be satisfactorily seasoned. Now the manufacturers handle these woods with comparatively little trouble; and their products are popular for a multitude of purposes, some of which are most exacting.

Since most of the softwoods are very easily kiln-dried with little damage, many of them are artificially seasoned to reduce the shipping weight and save the time required for air-seasoning. Much of the Southern yellow pine and the Western fir and cedar go straight from the sawmill to the dry-kiln, and then into cars for

shipment to market. As the hardwoods are more difficult to handle, they are ordinarily air-dried by the lumber manufacturer, and kiln-dried at the factory where they are re-worked into flooring, finish, and other products.

AIR-DRYING

Lumber may be air-dried at the sawmill for a few months to a year, before it is ready to ship to consuming points. The time required to reach shipping condition depends upon weather, season of the year, kind of timber, and climate. Inch pine lumber may dry to shipping condition in two months in the Southwest in summer; while, in the damp climate of the Gulf Coast, cypress manufacturers may find it necessary to hold lumber in their yards for a year to bring it to shipping condition.

Quick and satisfactory air-drying of lumber is secured by following certain principles which are recognized by all experienced lumbermen. These are to have solid foundations so that the piles will not settle out of shape; to have a good clearance above ground, and the piles sufficiently open to give free circulation of air; to have enough cross-pieces regularly placed to hold the boards straight while they are seasoning; and to give sufficient slope to the piles, and have them well covered so that water will run off quickly. A careful observance of these principles will produce straight, bright stock under

conditions which would result in very poor stock if the lumber were not properly piled.

There is a common theory that if timber is cut in the winter "while the sap is down," it is much superior to summer-cut timber in strength, resistance to decay, and other desirable qualities. As a matter of fact, while there are certain advantages in winter cutting, there is absolutely nothing to the notion that the sap is "down" in winter and "up" in summer. There is practically no difference between winter and summer in the amount of water which the wood of a tree contains. Winter-cut wood seasons best because it dries out more slowly and evenly, with less checking and warping, than summer-cut wood. It is also less liable to attacks of fungi, which produce decay or stain. Since the hardwoods are more difficult to season than the softwoods, the latter are less likely to sustain injurious effects from summer cutting. In the North, therefore, many operators saw mostly hardwoods in the winter and spring, and softwoods —pine and hemlock—in the summer and fall. However, many lumbermen cut timber the year round as it runs in the forest, and experience no special difficulty in either handling or marketing their stock.

A recent innovation in lumber seasoning for which much is claimed is a preliminary steaming in a tight cylinder before the lumber is piled in the yard to air-dry in the usual fashion. It is said that the steamed lumber air-dries much

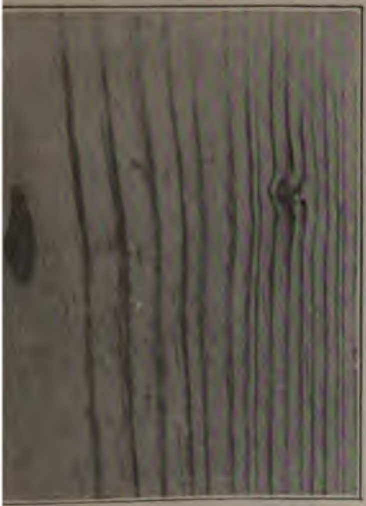
more quickly and with less checking and warping than does unsteamed lumber. It is also claimed that lumber cut from logs which have been in the water for some time, seasons better than lumber cut from logs which go straight from the stump to the mill. Both the steaming and the water-soaking seem to dissolve some of the contents of the cells in the sapwood, and open the wood up so that it subsequently seasons more uniformly.

KILN-DRYING

The artificial seasoning of lumber has made such rapid strides in recent years that it is now claimed, on good authority, that lumber of almost any kind can be kiln-dried in comparatively short time, with less damage than results from air-drying. However, many users insist that only air-dried lumber is fit for the most exacting purposes. This opinion is due very largely to the poor work done by the early types of kilns, which were neither scientifically constructed nor properly operated.

The rate at which lumber seasons is determined by three factors—temperature, humidity, and air circulation. All of these factors admit of regulation in a kiln; hence it is fair to assume that it is feasible to obtain favorable combinations of them which will rarely be found under natural conditions.

Kinds of Kilns. Kilns for drying lumber are of three general types:



Pin Knot

Pitch Streak

Spike Knot

Pitch Pocket

er and Its Uses

A Douglas Fir Forest

Plate 11—Lumber and Its Uses

(1) The dry air kiln, which is now generally obsolete because it produced so much case-hardened and honeycombed lumber.*

(2) The moist air kiln, of which there are several modifications according to the methods used to regulate circulation and humidity.

(3) The kiln which uses superheated steam.

Whatever make or type of kiln is used, its successful operation requires adherence to the following principles according to the authority of the United States Forest Service:

(1) The timber should be heated through before drying begins.

(2) The air should be very humid at the beginning of the drying process, and be made drier only gradually.

(3) The temperature of the lumber must be maintained uniformly throughout the entire pile. For this an exceedingly large circulation of air is essential.

(4) Control of the drying process at any given temperature must be secured by controlling the relative humidity, not by decreasing the circulation.

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* Case-hardening and honeycombing may be explained thus: Suppose a block of wood is very wet, and is placed in a kiln at too high a temperature and too low a humidity. The surface begins to dry and tends to shrink, but is prevented from doing so by the wet interior. Being plastic, it yields to this resistance and becomes stretched. If not plastic, it will check open. As drying proceeds, the surface hardens and sets in an expanded condition, and acts as a strong shell. The interior now dries very slowly, does not become set, but shrinks; and, as the exterior is already hard, it opens up or "honeycombs." When the exterior once becomes set or "case-hardened," the interior is almost certain to become honeycombed, whether the drying takes places in the kiln or a long time afterward. The only remedy is to moisten the exterior by steaming or soaking before it is too late. Air-dried material may also case-harden and honeycomb.

(5) In general, high temperatures permit more rapid drying than do lower ones. The higher the temperature of the lumber, the more efficient is the kiln. It is believed that temperatures as high as the boiling point are not injurious to most woods, provided the humidity of the surrounding air is great enough. Some species, however, may not be able to stand as high temperatures as others.

(6) The degree of dryness attained, where strength is the prime requisite, should not exceed that at which the wood is to be used.

Kilns which most nearly conform to these principles of operation yield a product which is superior to ordinary air-dried lumber, since it warps, checks, and stains less in the seasoning process, and will reabsorb from the air from 15 to 25 per cent less moisture than air-dried lumber. This reduction in the ability of the wood to absorb moisture—or, as it is technically called, its "hygroscopicity"—is very important, because it means a reduction in the extent to which the wood will swell or shrink under atmospheric changes.

WOOD PRESERVATION

SOME kinds of timber rot quickly after cutting; others last for many years, even under severe conditions. No hard and fast line can be drawn between woods which are durable and those which are not, since much depends upon the proportions of sapwood and heartwood, the amount of seasoning, and the situation in which the timber is used. Neither is it possible to say that any one kind of timber is superior to all other kinds in durability, or that the softwoods as a group resist decay better than the hardwoods, or vice versa.

Among the woods which are generally recognized as possessing much natural durability, are the cedars, redwood, cypress, osage orange, and black locust. Posts, poles, and ties made of these woods are often sound after many years of service under conditions favorable to decay. On the other hand, timber of naturally durable woods which is not seasoned before it is used, or which contains a very large amount of sapwood, may rot quickly; while properly handled timber of the less durable woods may last a long time. Timber like maple, gum, or birch rots quickly if used for a post or railroad tie without preservative treatment, while, if seasoned and used for house finish, it lasts indefinitely.

WHAT DECAY IS

Authorities estimate that the equivalent of nearly eight billion board feet of timber is annually destroyed by decay in the United States. This consists chiefly of lumber used for building purposes in places where most likely to decay, together with railroad ties. posts, poles, and mine timbers.

The decay of timber is caused by minute organisms called bacteria and fungi. They feed upon wood, and change it as completely as the digestive processes change the material upon which the higher forms of life feed. Sapwood is the most liable to decay, because it contains much more food for bacteria and fungi than does heartwood. The conditions which permit the growth of decay-causing organisms in wood are requisite amounts of heat, air, and moisture. These conditions usually exist in the most favorable combination at or just below the surface of the ground; so it is at these points that timber rots most quickly. The entire absence of either heat, air, or moisture, makes decay impossible. Timber kept either absolutely dry or absolutely wet lasts indefinitely, if not subject to wear. Sound timber found in the tombs of Egypt is an example of the former; and sound timber found in the Thames, dating from the Roman occupation of England, is an example of the latter.

HOW DECAY IS PREVENTED

Decay of timber is prevented by treating it

with antiseptics, or substances which are poisonous to bacteria and fungi. There are, of course, many such substances; but practical considerations make only a few of them suitable for commercial use. One of the first essentials of a good wood preservative is that it shall not dissolve out when the wood gets wet or is placed in water. For this purpose the best material so far discovered is creosote, a complex product of the distillation of coal tar. For comparatively dry situations, zinc chloride is a cheap and effective preservative; but it cannot be used for the treatment of timbers which are placed in water or in wet situations, because it leaches out quickly. Many experiments have been and are being made with various oils and distillation products; and, no doubt, other wood preservatives will be developed.

Paint lengthens the life of wood because it keeps out moisture and closes openings through which fungi might enter; but it is essential that wood be well seasoned before it is painted.

The rapid growth of the timber-treating industry may be judged from the fact that the first successful wood-preserving plants in the United States were built about 1870. In 1904 there were 35 such plants; and at present there are more than 90, with an annual output in excess of 125 million cubic feet of treated timber, of which by far the larger portion consists of railway ties and telegraph and telephone poles.

How Preservatives Are Applied

There are three general methods of applying wood preservatives—the brush method, the pressure method, and the open-tank method.

Brush Method. The brush method consists in applying the preservative with a brush in the same manner as paint. It is the least effective method, because of the very slight penetration obtained. It is useful, however, in cases where the preservatives cannot be forced into the wood, in painting the joints in timbers, the bottom of barges, etc.

Pressure Method. In the pressure process, the general features are practically the same, irrespective of the kind of preservative used. The timber to be treated is placed upon small cars, and run into large steel cylinders that are fitted with swinging doors. When the wood is in the cylinder, the doors are bolted fast, and the whole made practically air-tight. Saturated steam is then forced into the cylinder; and the wood is heated for five to fifteen hours, depending chiefly upon the amount of moisture it contains. It is claimed that by this steaming process the sap in the wood is heated and all the germs of decay destroyed. At the conclusion of the steaming, a powerful vacuum is applied, and held for one to three hours. This vacuum draws out the moisture and sap in the wood, and leaves it in a condition ready for the reception of the preservative. As soon as the moisture has been withdrawn, a valve is opened, and

the preservative material is permitted to flow in. When the cylinder is completely filled with the preservative solution, force pumps are started and pressure applied until the gages indicate that the amount of solution required has been absorbed by the wood. The liquid is then run out of the cylinder, the doors opened, and the treated material removed.

The pressure method is the one in general use throughout the country for treating timber thoroughly and on a large scale.

Open-Tank Method. A plant for the treating of timber by the pressure process is expensive, and can be erected only by firms of considerable capital. In order to devise means whereby the smaller sizes of timber, and especially posts, can be cheaply treated, the Forest Service has for many years been experimenting with what is known as the "open-tank" method.

The theory of this method of treatment is as follows: All wood is of a more or less porous nature, and contains a considerable amount of air. When placed in hot oil, for example, and heated, a part of the air and moisture contained in the wood is driven out. If the wood, while still hot, is plunged quickly into a bath of cold liquid, the small amount of air and moisture remaining in the wood will contract, and in so doing draw in the liquid.

If it is desired to save the expense of having two tanks—one for the hot and the other for the cold preservative—substantially the

same results can be obtained more slowly by withdrawing the heat and allowing the hot tank to get cold.

A simple open-tank device successfully used by the Forest Service in treating fence posts is described as follows:

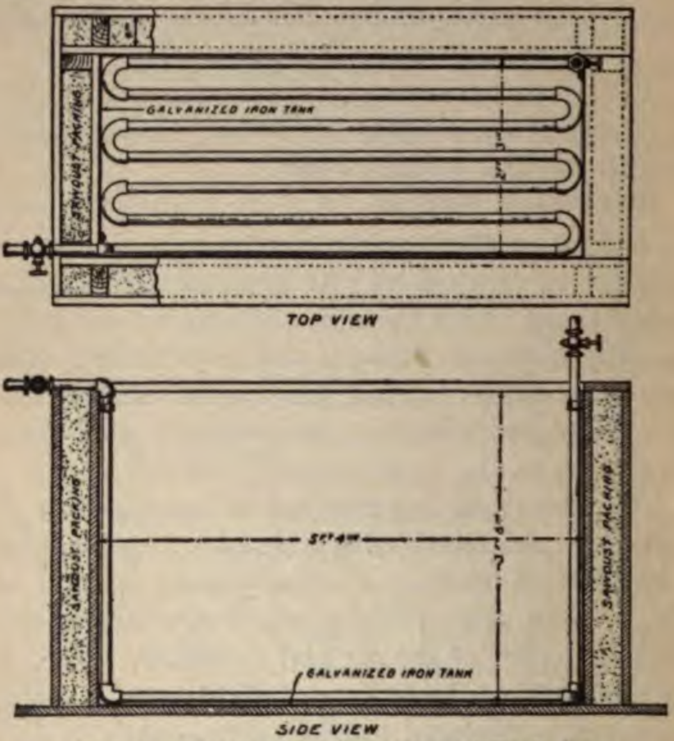

Fig. 8. Details of Construction of Tank for Treatment of Fence-Posts

The apparatus consists of a rectangular galvanized-iron tank 5 feet 4 inches long, 2 feet 3 inches wide, and 3 feet 6 inches high. This tank is set snugly into a wooden box built of 1-inch planks and open at the top. The object of this box is to keep the tank from bulging

when filled with creosote, to protect the tank from injury, and to keep the creosote from cooling too rapidly. When the posts are treated in winter or in cold regions, it is best to build an additional casing around the inner box, leaving a space of about 4 inches between them, and firmly packing this space with sawdust. The creosote will then seldom solidify over night, and may be more quickly heated.

The creosote is heated by fitting a series of seven 1-inch steam pipes in the bottom of the tank, coupled to the boiler of an engine. The amount of steam passing through the pipes is controlled by two valves—one placed between the tank and the boiler, to regulate the amount of steam entering the coils; and the other at the outlet of the coils, to control the pressure. By raising or lowering the pressure of steam in the coils, the creosote can be heated to any temperature desired. An apparatus of this kind makes it possible to keep the temperature of the creosote fairly constant, and gives very satisfactory results. It can of course be used only when some kind of steam boiler is available. It costs about $30.

Tanks built along the lines indicated give best results; but if means are not available for their construction, an old iron boiler or like vessel may be used. The essential requirements are that the creosote shall be heated in the vessel to about 215° F., and that the butts of the posts shall be submerged up to about 6 inches above their ground line. In special cases, where a thorough top treatment is necessary, the vessel should be of sufficient size to allow the whole post to be submerged.

The principal advantages of the open-tank method are that it is simple, comparatively cheap, especially adapted to the treating of small-sized material such as fence-posts, cross-ties, and mine timbers, and that with it prac-

tically any timber which has a fair amount of sapwood can be successfully treated.

The cost of an open-tank equipment for the treatment of posts, ties, and small timbers may range anywhere from $50 to $500, depending upon its completeness.

Bluing of Timber

The sapwood of timber or lumber cut in warm, damp weather is very likely to "blue" or stain while air-drying. This discoloration does not lessen the strength of the wood; but it does damage the appearance, and affects the market value for many purposes. Sap stain is supposed to be caused by fungi of a different kind from those which produce decay, and is preventable by comparatively simple means. If the freshly cut lumber is dipped in a 6 to 12 per cent solution of bicarbonate of soda, and then piled in open fashion so that air circulates freely among the boards, there will be practically no bluing. There are few bad effects from the soda treatment, and it is not expensive; so it has been adopted by many lumber manufacturers—especially in the South, where staining is most likely to occur. A simple device carries the lumber on an endless chain through a tank of soda solution at the tail of the sawmill.

Protection from Marine Borers

On the seacoast, piling and dock timbers are often destroyed by marine borers (usually teredo

or shipworms), even more quickly than timber on land is destroyed by decay. The annual loss from this source is very great. In fact, in many places it is almost impossible to use wooden piles unless they are protected from borers. The best method of giving such protection is to apply a creosote treatment, since creosote is as distasteful to marine borers as it is to decay producing fungi. Well-creosoted yellow pine piles have been known to give 30 years or more of service in situations where, if unprotected, they would have been destroyed in a single year. The fierceness of the attack of these borers is indicated by the examples shown in the illustration (Plate 24).

SAVINGS DUE TO WOOD PRESERVATION

The following, based on estimates of the Forest Service, are typical examples of the financial saving which may be made by wood preservation:

Fence-Posts. An untreated loblolly pine fence-post costs about 8 cents, or, including the cost of setting, 14 cents. Its length of life in this condition is about two years. Compounding interest at 5 per cent, the annual charge on such a post is 7.53 cents; that is, it costs 7.53 cents a year to keep such a post in service. If given a preservative treatment, which costs about 10 cents, the length of life of the post is increased to about eighteen years. The total cost of such post, set, is then 24 cents, which, compounded at the above interest rate, gives an annual charge of 2.04 cents. Thus the saving due to treatment is 5.49 cents a year. Assuming that there are 200 posts per mile, there is a saving each year for every mile of fence of a sum equivalent to the interest on $219.60.

Railroad Ties. A loblolly pine tie untreated is worth about 30 cents, and its length of life in this condition is about five

years. To this first cost should be added the cost of laying, which is about 20 cents. The annual charge, figured as above, is then 11.52 cents. If treated, it will last for about twelve years. Its cost of treatment is about 35 cents. A treated tie in the track, therefore, costs about 85 cents. Compounded at 5 per cent, as in the above example, the annual charge is 9.48 cents. The saving per year is therefore 2.04 cents per tie. Assuming 2,880 ties per mile of track, the saving due to treatment alone amounts to $58.75 per mile, which corresponds to an investment of $1,175 per mile.

Poles. Assuming that the cost of an untreated oldfield or loblolly pine pole, including hauling and setting, is $5, and that it lasts five years—a fair estimate for many portions of the United States—the annual charge, compounding interest at 5 per cent, amounts to $1.15. In other words, it costs the owner $1.15 a year for every such pole in his lines. This corresponds to a capital of $23 invested at 5 per cent interest, or, for a mile of 40 poles, to $920. Again, assuming that the butt of such a pole can be treated for $1, the first cost of the pole, set in the ground, is $6. The treatment may reasonably be expected to secure a service from the pole of twenty years, instead of five years when untreated. Thus the annual charge on the treated pole, with the same rate of compound interest, is only $0.48 per pole, which corresponds to an investment of $9.60—or $384 per mile, as compared with the $920 per mile in the other case. Thus, during the life of the treated pole, a yearly saving of the interest on $536 will be effected for every mile of line.

There is abundant evidence of the long life of creosoted wood. Even in this country, there are many examples of poles and other timbers creosoted 20 and even 30 years ago, which today are apparently as sound as when first set in the ground. In Europe, where wood preservation is an older industry, the results are still more marked. There have been failures; but in every instance they can be traced to incompetent or fraudulent work, insufficient impregnation, improper preparation of the timber, or some similar cause.

PAINTS AND STAINS

PAINTS and stains are used for two purposes—first, to preserve timber; and second, to secure decorative effects. Paint acts as a wood preservative because it closes the openings in the wood and prevents the entrance of moisture and decay-producing organisms. A thoroughly seasoned piece of wood will last indefinitely if kept well painted.

The general distinction between paints and stains is that a paint is an opaque covering which to a greater or less degree conceals the natural appearance of the surface to which it is applied. A stain or varnish on the other hand, either brings out more strongly the natural appearance of the wood, or modifies it to a degree depending upon the character of the stain without obliterating the natural figure. Paints are more largely used for exteriors, where protection is the chief object; and stains for interiors, where decorative features are the main consideration, although paints are also much used for interior work.

PAINTS

Paint is made by mixing and grinding certain solid substances in linseed oil or other liquids. The solids are termed "pigments," and the liquid in which they are ground is called the

"vehicle." To these are added a wide variety of colored pigments if colored paints are desired.

The most common and the best pigments are white lead and zinc oxide; and the most useful vehicle, linseed oil—these forming the basis of nearly all the best paints. Turpentine is generally added to paint to make it more fluid, and hence easier to spread. Several substances called "driers," usually lead or manganese salts dissolved in oil or turepntine, are also used with paint to make it dry more rapidly. Colored paints made upon a white lead or zinc white base are most serviceable, and last longer than pure white paints.

A number of important points must be observed, or good results will not be secured in painting, no matter how good the paint may be. In the first place, the surface to be painted should be thoroughly cleaned and dry; and, if it has been painted previously, every bit of old, loose paint should be completely removed. All nail holes and cracks should be well filled with pure whiting and linseed oil putty. Knots or sappy places in the wood should be coated with some material which will prevent any matter in the wood from exuding and causing blisters. The best coating for this purpose is pure orange shellac. Paint should always be applied in thin coats well distributed. Three thin coats of paint will give much more wear than two heavy coats, although they require less material. Moreover,

ample time should be allowed between coats, for thorough drying. Autumn is usually considered the best season of the year for painting, because of slower drying and less likelihood of blisters forming in the hot sun; but with proper care, good exterior painting can be done at any time of the year.

STAINS

The finishing of interior woodwork, and particularly of the finer woods, calls for good knowledge of materials and careful workmanship. All high-class jobs of this sort require several applications and manipulations. Moreover, the finishing must be varied according to the character of the wood used. The more porous or open-grained woods are usually given a paste filler carrying some color before stains are applied, while the less porous or close-grained woods can be brought to a state of fine finish without the use of fillers.

Wood finishers usually classify oak, walnut, ash, butternut, chestnut, and mahogany as open-grained woods with which a paste filler is advisable for a fine finish; while in the class of close-grained woods, where such a filler is not necessary although sometimes used, they put birch, cherry, maple, circassian walnut, gum, white and yellow pine, basswood, spruce, fir, redwood, cedar, and yellow poplar.

Stains are usually designated as "spirit," "oil," or "water" stains, depending upon the

vehicle in which the colors are mixed. Spirit stains are usually made with alcohol. It is claimed that the alcohol evaporates so quickly that it is impossible to apply spirit stains evenly on a large surface. Oil stains are used most largely on close-grained woods, and give a smooth finish with excellent effect, but are said to be somewhat less transparent than water stains. The users of water stains claim that they produce clear, transparent colors, and that they can be evenly and quickly applied on all kinds of wood, and also are susceptible to any subsequent method of finishing.

After the wood is stained, the next step is the application of a finishing coat or varnish to preserve the stain. The number of coats of varnish applied depends upon the fineness of finish desired. It may be two or three on woodwork, or a large number on a high-class article like a piano case. Finishes may be gloss finishes, rubbed finishes, or rubbed and polished finishes, depending upon the manner in which applied. Moreover, there are flat finishes which produce the effect of a mission or rubbed finish without rubbing, and so are often used at a material saving in cost.

In the finishing of interior woodwork, it is especially important that the surface be absolutely clean and dry. It is also necessary that the room in which varnish is used be kept as nearly as possible to a temperature of 70°; for if it is cold, the varnish will not set properly.

Dense Stand of Longleaf Pine

-Lumber and Its Uses

Second-Growth White Pine—Trees 50 to 60 Years Old

Plate 13—Lumber and Its Uses

There are many manufacturers of reliable paints and stains of all kinds, who will promptly supply samples of their products upon application.

FLOOR FINISHES

One of the most notable developments of lumber manufacture in recent years has been the production of flooring materials of great serviceability from many different woods, the most prominent of which are maple, beech, birch, oak, edge-grain yellow pine, and Douglas fir. The use of such floors has become so popular and widespread that it is worth while to quote from Radford's "Estimating and Contracting" as follows, upon the finishing of floors:

"The first thing necessary in order to obtain a good job of floor finishing, is to get a perfectly smooth surface. Until recently the only way to do this was the tedious, back-breaking method of planing and scraping, the latter being done usually with the edge of a freshly cut piece of glass. When the cutting edge wears down, a fresh piece must be taken. Sandpaper, bent over a flat wooden block, is also used to cut down any roughness or raised grain. Steel wool is preferable for this purpose, on account of the greater rapidity with which it cuts. While this method is still very generally practiced, modern invention has come to the aid of the floor finisher and has produced a planing machine or surfacer that is pushed across the floor like a lawn mower.

"The first operation is filling the wood. Oak and other open-grained woods require filling with a paste filler; and while many painters laugh at the idea of a paste filler upon such woods as yellow pine and maple, experienced floor finishers say that a better job can be done

by using paste filler as a surfacer. The method of using is to apply the filler to a strip, say six or eight boards wide, running the entire length of the room. Use a short, stiff brush, and apply across the grain. By the time this strip has been completed, the filler will probably have set sufficiently to rub. It must not be rubbed before setting, or it will be rubbed off the wood; nor must it be allowed to set too hard, or it will be impossible to rub it at all or even to scrape off the filler. When the strip has set just enough, it must be rubbed well into the grain of the wood. After the filler has been thoroughly rubbed, any surplus material must be carefully wiped off with a soft rag. Before anything further can be done, the filler must be given time to dry —not less than 24 hours, and preferably two days.

"If the natural color of the floor boards is not satisfactory, they should be stained before filling; and the filler should be colored with pigment ground in oil, to bring it to the same color tone.

"If there are cracks or nail-holes in the floor, they must next be filled, in order to make a smooth and perfectly uniform surface. This filling may be done by using a pure whiting and linseed oil putty, tinted to match the floor boards; or it may be done better with a whiting and white lead putty made by mixing one part of white lead in oil with two or three parts of bolted whiting and enough coach varnish to make a stiff paste. This putty will resist moisture; and, when dry and hard, it may be sandpapered or rubbed. For large cracks, an excellent unshrinkable putty can be made by soaking blotting paper in boiling water until it forms a pulp, then mixing it with glue dissolved in water. To this, bolted whiting is added in sufficient quantities to make a fairly stiff paste, and thoroughly kneaded. This paste must be pressed into the cracks and smoothed off with a putty knife.

"For those who do not care to make their own putty,

there are excellent prepared crack-fillers on the market.

"**Wax Finish.** By far the best material for finishing hardwood floors is wax, although this involves a little more trouble to keep in good condition. It gives a smooth, satiny luster, without the glaring effect of new varnish, and is not marred by heel-prints such as varnish is subject to. When wax grows dim, it can readily be polished again.

"Some painters advocate the application of the wax directly upon the paste filler; but the best practice is first to give one or two thin coats of pure shellac varnish. Where a slight darkening of the tone of the wood is no objection, orange or brown shellac is preferable to the bleached, since it is stronger. Shellac should be cut with grain alcohol, and not with wood alcohol. It is especially adapted where a hard and quick-drying undercoat is required. On a close-grained wood where a paste filler has not been used, either a thin coat of a first-class liquid filler, or a coat of one part of linseed oil to which from five to ten parts of turpentine have been added, should be given before applying the shellac. Unless there is an undercoating of some kind, it is very difficult to apply the shellac so that it does not show the lap. Even then it requires skill and rapidity of work. In shellacing a floor, the plan of following down a space one or two boards wide should always be followed. The shellac coat should be put on before the oil or liquid filler coat is absolutely dry.

"After shellac has become dry, the wax, in paste form, is applied with a rag or a brush, and, after a short time, is brought to a polish by means of a weighted brush or by rubbing with a cloth. Only a very thin coat of wax is necessary, a very little more being occasionally added.

"Quite a large number of specially prepared floor-polishing waxes are on the market, and care should be taken to select a material of this kind that will give a hard polish and will not remain soft and sticky. It was the

softness of the old-fashioned beeswax and turpentine that caused the almost endless labor needed to keep floors in perfect condition. Modern wax finishes are made by combining beeswax or paraffine with some of the fossil waxes, or from the latter alone, giving a much harder surface. In general, the wax which has the highest melting point is best for the manufacture of floor waxes, because it is the hardest after application. Carnauba wax has a high melting point (185° F.), and may be used alone as a floor wax by melting it in a suitable kettle and thinning it with spirits of turpentine so that, in cooling, it has the consistency of soft tallow. In this condition it can be applied with a large brush.

"Two coats of wax on a new floor are better than one—the first coat being required to fill up, and the second to give luster—although, if sufficient polish is obtained by the first coat, the second will be found unnecessary.

"The preparation of wax finish is attended with so much risk from fire that it should be undertaken only over a water bath. Even then, it is wiser for the ordinary painter to buy the prepared wax than to undertake to make it.

"**Varnish Finish.** A large number of floor varnishes are on the market. These varnishes, as a rule, are designed to harden over night. The surface should be prepared in the same way as for wax finish; and after the filler is bone-dry, two or more coats of varnish should be applied. If desired, the varnish may be rubbed to a dead surface with pumice stone and kerosene. Practically every varnish will show heel marks, and will mar white by use. When the surface becomes worn, the old varnish requires to be either scraped off or removed with a varnish remover before a new coat of varnish can be applied; while, with a wax, all that is necessary to restore the surface to a good condition is to apply a little more wax and use the polishing brush.

"When a waxed floor gets dirty and shabby, it can

be cleaned down to the shellac with turpentine, and rewaxed at a small cost. It is well to give a special caution against using a wax finish over a varnish coating, since the wax will soften up the varnish and cause trouble.

"**Oil Finish.** A very satisfactory finish for rooms that have hard wear, such as schoolrooms, stores, and rooms in public buildings, is first to fill the floors, and then give them two thin coats of shellac, finally applying a very thin coat of paraffine oil, or of a rubbing and polishing oil, with a brush or a rag, and thoroughly wiping off any surplus remaining on the surface. This oiling should be repeated every few days, according to the amount of wear that the floor gets. This same treatment is specially adapted for kitchen floors, dining rooms, and other floors in private houses that are subject to hard wear. It is also well adapted to the cheaper floors, such as yellow pine or spruce. If mud has been tracked on the floor, it should first be mopped up with water, and this should be allowed to dry before oiling. One advantage of the oiled floor is that it is ready for use as soon as the oiling is finished. This same method of oiling can be used over a varnished floor, and will preserve it from marring.

"Besides paraffine oil, crude petroleum may be used, or any of the so-called polishing oils or furniture polishes. Such oils can be made from machine oil or sweet oil and oil of lemon.

"**Painted Floors.** A floor finish not in such general use as it deserves, is the painted floor. Paint has the advantage of hiding inferior floor boards and being cheap. There are a number of special floor paints on the market for use on kitchen floors and other rooms having a good deal of wear.

"A painted floor can be made quite ornamental by the use of a stenciled border, which should be put on before the varnish coats. The most appropriate designs are those which resemble mosaic work in their effects, or

interlacing strap work. When the colors are properly chosen, care being taken to avoid glaring contrasts, a painted and stenciled floor is fully as effective as a hardwood floor; and it possesses one distinct advantage in that it can be adapted to any decorative color scheme for the room.

"A floor that is grained, especially one grained in oak, has one of the most durable finishes that can be given, requiring very little attention other than wiping up with damp cloth or mop. If well done, it is fully as effective as a hardwood floor."

SHINGLE STAINS

The popularity of bungalows and drop shingle construction has greatly increased the use of shingle stains. There are many such stains on the market, of good quality, made by various manufacturers. Several of them contain some creosote, which incerases their preservative power; while any desired effect is produced by the addition of coloring matter. Shingles are often dipped in stains before laying. This is the best method of application, since the stain or preservative thus reaches all parts of the surface, and also penetrates any openings in the shingles. A large number of shingles can be dipped in a short time, so that the cost is not great, while both the lasting qualities of the shingle and the appearance are greatly improved. (For specifications for staining shingles, see page 108.)

If a shingle stain which has a lead base is desired, the following preparation published by Radford will be found useful:

A good shingle stain may be made by using pure white lead (in oil), strong chrome green (in oil), raw umber, and a little lampblack, mixed until the desired shade is reached, thinning with boiled linseed oil and a little japan. To 1 quart of this paint, add, for dipping purposes, 5 quarts creosote oil; and for application with the brush, mix 1 quart of the oil paint and 3 quarts of creosote oil. A common estimate is that 3½ gallons of stain will be sufficient for 1,000 shingles, dipping two-thirds of the shingle.

The following estimate of the covering capacity of shingle stain is based on the average cedar shingle, size 4 by 16 in.

One gallon of stain will cover 150 sq. ft. one brush coat, or 100 sq. ft. two brush coats.

Two and one-half to 3¾ gallons of stain will dip 1,000 shingles, two-thirds of length of shingle to be dipped.

Three gallons of stain will dip and brush-coat 1,000 shingles in some cases.

The covering capacity of creosote bleaching oil is about one-fifth less than the above figures.

The protection of shingles from fire by means of special paints is discussed in the chapter on "Fire Resistance."

ARCHITECTURAL SPECIFICATIONS FOR PAINTING, STAINING, ETC.

Architectural specifications for the painting, enameling, staining, and finishing of woods for first-class and medium grades of work, prepared by Mr. John Dewar at the request of the Master House Painters and Decorators of Pennsylvania, were endorsed by that Association, January 15, 1913. The essential portions of these specifications are quoted as follows:

Painting New Exterior Woodwork

Medium—All knots, rosin, and sap portions shall be properly shellaced. Paint one coat white priming brushed well into the wood, after which all nail-holes, open joints, and other imperfections shall be closed solid with putty containing 20 per cent white lead; then apply two coats of paint, colors to be selected. Each coat must be thoroughly dry before the application of another. Paint the back of all window and door frames one coat before setting, sash runners of window frames to receive two coats of oil, stained if required, the last coat to be applied at completion. No paint to be applied during wet or foggy weather. (See Note 1, below.)

First-Class—Woodwork should be painted as above specified, using one additional coat.

NOTE 1—All authorities agree that pure raw linseed oil and pure spirits of turpentine are the best vehicles for exterior paints. The vehicle of first or priming coat on new wood, also second coat, should consist of 80 per cent pure raw linseed oil and 20 per cent pure spirits of turpentine, the final coat 90 per cent pure raw linseed oil and 10 per cent pure spirits of turpentine, all to contain necessary driers. When four coats are used, the first, second, and third coats should be composed of 80 per cent oil and 20 per cent turpentine, the fourth coat 90 per cent oil and 10 per cent turpentine.

There exists some diversity of opinion as to the best paint pigment or pigments in combination. How necessary it should be that the construction of a paint film be as near perfect as possible. The necessity of this should be apparent to us all, especially when we are confronted with the fact that "the average paint coating is only three one-thousands of an inch thick, and yet this thin coating is required to withstand expansion and contraction of the underlying surface, abrasion or wear from storms of dust and sand, or rain, sleet, hail, and absorbing, drawing, and expanding influences of the summer's sun, and contraction from the cold of winter. It must have both hardness, to withstand to a rea-

sonable extent this surface wear, and yet enough elasticity to meet internal strain and to conform to changes in the underlying surface; and it must penetrate and cling to the surface upon which it is applied. It must also retard and prevent from access to the underlying surface both the moisture and atmospheric gases which cause decay;" and, if possessing the virtues of a good paint, it must in the course of time, when repainting becomes necessary, present a suitable foundation for the new paint coatings.

It is generally accepted that a white or tinted base paint containing about 75 per cent white lead and 25 per cent zinc oxide is of a high standard. When used near or at the sea shore, also in the Southern States, it can be improved by a change to the following: 60 per cent white lead and 40 per cent zinc oxide. The purpose in combining these two best paint pigments are, that the one makes strong the weak points of the other, giving us an ideal paint coating. The zinc makes the film stronger and harder, also practically non-absorbent by reason of these qualities, and, with its fineness of texture, fills up the voids caused by the coarser pigment. After a most thorough and practical personal investigation as to results, I recommended the above combination, having used them in my practice for years. I have the manufacturer combine and grind the two pigments together, thereby getting a thorough amalgamation.

When the result required is a white or color-tinted paint, it is advisable to use the same percentage of different basic pigments and coloring matter in all of the coats, on account of obtaining a uniform expansion and contraction, solidity of color, etc.

When "Prepared Mixed Paints" in paste form are used, the limit of inert pigments should be 15 per cent. This percentage may be composed of barytes, silica, or asbestine, or a mixture of such pigments. To this amount there should be no objection, as, up to that extent, these inerts have their values as part of a good paint film; but vehicle proportions as set forth should be followed.

The use of asbestine is principally to hold up in suspension the heavier pigments in the paint, its fluffy and rod-like form being valuable for this purpose. It is also said to act as a reinforcing pigment in the same way that iron bars act in reinforcing concrete structures.

Straight white lead makes a splendid primer. Ochre should never be used, nor boiled linseed oil for undercoatings. When the color of the finishing coat is required to be a strong solid color such as green, red, etc., by using these strong colored paints from the foundation up, you will not get a solidity of body; therefore I would suggest the use of a strong tinted white base for undercoatings.

In the painting of cypress and Southern yellow pine, the vehicle in the priming coat, and priming coat only, should be 40 per cent of 160 degree benzole, 10 per cent pure spirits of turpentine, and 50 per cent pure raw linseed oil, proceeding with the subsequent coat as specified above. The character of these woods is such as will not permit of the penetration of paint made by the usual vehicle practice. With the turpentine and the addition of benzole, which is one of the greatest penetrating solvents of rosin, gums, and grease known, they carry the oil and pigment, when well brushed out, into the wood; and it there finds a lodgment, forming a substantial and permanent foundation for the subsequent coatings. The benzole, like turpentine, after performing its mission, evaporates entirely, leaving no residue.

From the beginning to the finish of a first-class residence, or other important operation, considerable time may elapse, not infrequently a year or more, therefore a necessity for the additional or fourth coat of paint. I would recommend for their distribution, after the priming or first coat and the necessary puttying up, that the second coat be applied, the third and fourth coats about the time of completion of building. Another substantial reason for the fourth coat is that the householder, realizing that he has a new residence, is usually less watchful as to any necessity for repainting for a term of years.

With the application of the priming coat when the work is first put in place, followed by the two coats probably six months or a year after, such a condition will of necessity require repainting in probably less than four years. This proves the economy of the fourth coat, which, under average conditions, lasts as a protective agency for probably six or seven years before the necessity for repainting arises.

Repainting of Exterior Woodwork

Remove such old paint as may be necessary from exterior woodwork by scraping, burning, or with paint remover as conditions may require. Sandpaper and touch up with paint one or two coats as found necessary, all of that portion from which the old paint has been removed. Paint all woodwork two coats, colors to be selected. Do all necessary sandpapering and puttying. (See Note 2.)

NOTE 2—In the work of repainting, it is practically impossible to specify intelligently without being familiar with conditions, as so much depends upon them.

The basic paint pigments should be as specified in "Note 1." The proportions of vehicles for first coat must be determined by conditions. For instance, if the vehicle of the old paint coatings is dried out, leaving an absorbing surface, hungry as it were, the vehicle for first coat should consist of about 75 per cent raw linseed oil and 25 per cent turpentine, second or final coat 90 per cent raw linseed oil and 10 per cent turpentine; or, if the surface be hard and non-absorbing, the proper proportions of vehicle for first coat should be about 50 per cent oil and 50 per cent turpentine, the final coat 90 per cent oil and 10 per cent turpentine. Not infrequently I have found it necessary in repainting, from a number of causes, to give all of the woodwork three coats.

The overcoming of these imperfect conditions and producing the best results possible, is largely a work of diagnosis consisting of about 75 per cent man and 25 per cent material. The remedy for the different ailments consists in the different proportions of the vehicle to meet the diversified conditions, and not with the pigments.

The paint burner ever being a menace, I would discourage its use where possible. In every instance I would have the owner of the building give his consent to its use; also that he notify his insurance company, and get a permit from it consenting to its use.

Staining of Exterior Woodwork

Medium—All exterior woodwork (or a portion as the

case may be) to receive one coat of linseed oil stain, brushed well and uniformly into the wood. Color to be as required. Pigments to be selected for their permanency of color. Vehicle to consist of 40 per cent of 160 degree benzole and 60 per cent raw linseed oil; all nail-holes and other imperfections to be closed with lead putty colored to match stain; then apply one good coat of raw linseed oil containing 10 per cent turpentine. (See Note 3.)

First-Class—Specify one additional coat of oil containing 10 per cent turpentine. (See Note 3.)

Staining Shingles—Dip shingles two-thirds their length in stain specified as above, color to be determined. After shingles are in position, touch up and apply one coat of linseed oil containing 10 per cent turpentine. (See Note 3.)

NOTE 3—This stain is suitable for all kinds of wood used for exterior finish. It must be remembered that a stain implies a transparent coloring, and not a paint coating which is opaque. If it is desired to stain oak or cypress to a dark green or a dark brown color usually used on the timbering and finish of houses designed after the old English period, two coats of stain should be specified to get the necessary depth of color. To attempt this with one coat would result practically in a paint coating, with a covering or hiding of the figure of the wood. If it is desired to stain oak silver grey or other light colors, but one coat is necessary. Shingles, owing to depth of color required, frequently require a second coat of stain after they are set in place. The use of benzole in the stain becomes the active penetrating factor, carrying the coloring matter and oil into the woods. It has about the same evaporating consistency as turpentine.

There being a substantial difference between a paint coating and a stain, therefore the stain specified can be used when necessary for both coats.

Where a perfectly flat surface is desired, the second coat of oil may be an objection; but for durability I would recommend it, also for the reason that the oil gloss shortly flattens down.

There are a number of very good shingle stains on the market.

Re-Staining of Exterior Woodwork

Prepare and re-stain all or such portion of exterior woodwork as may be found necessary, color conforming closely to original stain. Coat all stained woodwork with two coats of linseed oil containing 10 per cent turpentine. Between first and second coats, close up all imperfections with putty colored to match stain. (See Note 4.)

NOTE 4—Re-staining is also a work of diagnosis as to whether the entire work should be gone over with a light coat of stain, or a portion, where the former is badly used up, and whether it should have one or two coats of oil. In this case an examination will quickly speak for itself. A coat of oil over the old stain will make quite a difference in appearance of old color.

Plain Painting for Interior New Woodwork

Shellac all knots and sapwood; paint woodwork (locating same) three good coats, color to be selected. After the first or priming coat, close up with lead putty all nail-holes and other imperfections. Do all necessary sand-papering between coats. (See Note 13.)

NOTE 13—If color required be white or lightly tinted, the wood work should first receive one coat of shellac to prevent discolorations from resin and sapwood. If varnish coat should be required over paint, specify all painted work to receive one coat of a good wearing light color varnish, evenly applied.

Painting and Graining Interior New Woodwork

Shellac all knots and sapwood; paint all woodwork (locating same) two coats, no oil to be used in this paint other than that in which the lead is ground. In mixing, use a small quantity of a good mixing varnish, thinning with a turpentine so that the paint will dry with a flat eggshell gloss, sandpapering each coat perfectly smooth.

Grain in best manner in imitation of hardwood to be selected, the graining color to be used as flat as possible,

consistent with working out. Varnish all grained work one coat of a good wearing body varnish. (See Note 14.)

NOTE 14—If a first-class job is required, specify one additional coat of varnish to be full and evenly applied, each coat to be thoroughly dried before the application of another. If a flat finish is required, specify the last coat of varnish to be rubbed evenly to a flat finish with crude oil and pumice stone, all oil and pumice stone to be thoroughly cleaned off at completion.

A flat finish may be secured by using what is termed a "flat varnish." In the use of a flat varnish, two coats are required, the first being a gloss varnish. About 50 per cent of these varnishes contain a large percentage of wax over which you cannot apply at any future time paint or varnish, as neither will adhere permanently to a wax surface. The use of some of these flat varnishes is commendable, especially in producing certain results on natural hardwoods.

Graining is practically becoming a lost art, owing to the general use of hardwoods. Where the work is well done, this specification should produce splendid results. Some painters may not agreed with me in the number of coats and manner of mixing the ground coating; let them try it, and they will find no cracking or crazing of their varnish; but of course the varnish must be good, and undercoating perfectly dry.

Woods best adapted to painting and graining are birch, cherry, maple, poplar, and white pine.

Natural Finish for New Interior Softwoods

All woodwork shall be thoroughly gone over, cleaned up, and sandpapered where necessary, after which apply one coat of white shellac and two coats of a good wearing body varnish, the last coat to be evenly flowed on. After shellacing, close up all nail-holes and other imperfections with putty colored to match wood, being careful to rub off any surplus putty. Sandpaper thoroughly between coats. (See Note 15.)

NOTE 15—This would apply to white pine, poplar, yellow pine, cypress, etc. Sometimes a flat finish is required; in that case, specify rubbing with oil and pum-

ice stone to a dull even finish. I do not recommend close rubbing on two coats of varnish, as it must be kept in mind that close rubbing will practically remove one coat of varnish. I do not recommend any rubbing for servants' quarters, nor yet for the average medium job.

The natural color of these woods is sometimes an objection. In that case I add a "touch" of burnt sienna, or burnt and raw sienna, to the first coat of varnish, not sufficient to produce a stain, simply giving the wood a warm pleasing glow, removing the harshness of the natural color.

Staining and Varnishing New Interior Softwoods

All woodwork shall receive one light coat of 25 per cent linseed oil and 75 per cent turpentine. Sandpaper and stain in best manner, with an oil stain containing about 50 per cent turpentine; color to be selected. Close up all nail-holes and other imperfections with lead putty colored to match stain, being careful to wipe off any surplus putty marks. Varnish all stained work two good coats of a strong wearing body varnish, the last coat to be evenly flowed on. Sandpaper between coats, each coat to be thoroughly dry before another is applied. (See Note 16.)

NOTE 16—The purpose of applying a thin coat of oil to the woodwork before staining is that certain portions of the surface may be very much softer than others; in fact it may appear in spots, all over. With the application of the oil as specified, you in a measure stop the suction of those soft places, and get a practically uniform surface on which to work the stain. A thin coat of shellac instead of the oil might be used, but I prefer the oil as thinned with the turpentine, as I get a more uniform absorption into the wood for the stain, the shellac in a measure stopping absorption.

For a flat surface I would specify rubbing with oil and pumice stone to a dull finish; for close rubbing I would specify one additional coat of varnish. This specification would apply to white and yellow pine, poplar, cypress, etc.

Painting and Enameling Interior New Woodwork

Medium—All woodwork (specify location) shall be gone over carefully. Shellac all knots and sap portions. Prime with one thin coat of white paint, well brushed into the wood, after which sandpaper thoroughly, closing up all nail-holes and other imperfections with lead putty. Apply one medium coat of pure grain alcohol white shellac. Sandpaper lightly. Apply three coats of white paint consisting of about 60 per cent white lead and 40 per cent zinc oxide, and one coat of straight pure zinc oxide, followed by one coat of best enamel, freely and evenly applied, all coats to be tinted as required. Each coat must be thoroughly dry and well sandpapered before the application of another. (See Note 17.)

First-Class—Apply one additional coat to the above specification (four coats) after the shellac, followed by the straight zinc and two coats of best enamel, the last coat of enamel to be evenly rubbed with water and powdered pumice stone to a satin or china gloss finish. (See Notes 17 and 18.)

NOTE 17—With the application of a second coat of enamel, this specification may be rubbed with water and powdered pumice stone to a very good finish. If a semi-gloss or flat finish is desired with but one coat of enamel, reduce the enamel by mixing into it a portion of the straight zinc coater necessary to give the condition required. To fully obtain this result requires very careful brushing, so as not to show laps, brush marks, and cording; but it can be accomplished very nicely.

With the exception of the priming coat no oil should be used except such as may be found in the stiff lead and zinc; the priming coat should consist of about 40 per cent oil and 60 per cent turpentine, light of body and well brushed into the wood. I have my zinc for enameling purposes ground in poppy oil, which greatly minimizes the chances of the work turning yellow when confined to a dark room. The use of linseed oil is a strong factor in the work turning yellow when excluded from a

Mature Western Yellow Pine

Large, Clear White Pine Logs

Plate 14—Lumber and Its Uses

Lumbering Operations in Western Yellow Pine in a National Forest

strong light. In the preparation of my several under paint coatings, I use, instead of oil as a binder, a portion of a good mixing enamel varnish; each coat must be worked flat. In using the straight zinc oxide for a final coat of paint on this class of work, I find that I can get purer tints of greater variety, without the danger from chemical action that would result if I were to use some white leads.

The straight zinc coat, should have an "eggshell gloss" for the reason that, if it were perfectly flat such as the under paint coatings should be, it would absorb and draw the liquid properties from the enamel coat, leaving a surface of questionable uniformity.

The different coats of paint from the shellac up should be tinted as required for the finish, for by so doing you get a solidity of tint that you otherwise would not. For a perfect white job, we oftentimes "draw the lead;" that is, we break up the lead in turpentine to a thin consistency, permitting it to stand 24 hours, then pour the surface liquid off; and you have remaining lead practically free from oil. With the percentage of zinc oxide specified, and with the use of a good white enamel varnish, or—which is better—a portion of the enamel as a binder-reduced with pure turpentine to a working consistency, you have a ground work for enameling that will be satisfactory in every respect.

NOTE 18—This specification, if faithfully carried out, will produce splendid results. For this high class work, cherry, birch, or plain maple should be used; good results can be secured on white pine or poplar.

Varnishing and Finishing of Hardwoods

Medium—Sandpaper and remove all surface defects. Stain if desired. Fill with best paste filler, colored if necessary, thoroughly cleaning surface and moldings. Shellac one coat, and varnish two coats of a good varnish suitable for this purpose. After the shellac coat, close up all nail-holes and other imperfections with lead putty, colored as required, all surplus putty to be carefully wiped off. Sandpaper between each coat. Care must be taken during varnishing to keep the premises as free from dust as possible. (See Note 22.)

First-Class—Sandpaper and remove all surface defects. Stain if required. Fill with best paste filler, colored if necessary. Thoroughly clean all surfaces and moldings. Shellac one coat pure grain alcohol shellac, and varnish four coats of a first-class varnish designed for this class of work. Rub all varnish surfaces true and even, with oil and pumice stone, to a dull satin finish. Thoroughly clean all oil and pumice stone from surface. Each coat must be thoroughly dry and sandpapered before the application of another. Care must be taken during varnishing, to keep premises as free from dust as possible. (See Note 23.)

NOTE 22—If the location of the finish justifies additional expense and a flat surface is desired, specify that the last coat of varnish be lightly rubbed with oil and pumice stone to a uniform dull finish, thoroughly cleansing surface from all oil and pumice stone. In servants' portions of residences, this is not justifiable.

This specification pertains to all open-grained woods such as oak, ash, chestnut, black walnut, etc. If cherry, birch, maple, and such woods are used, frequently the filling with paste filler is eliminated, the shellac coating filling requirements. In my own operations, I invariably use the filler as specified, but quite thin in body, carefully wiping off filler from surface. For birch stained in imitation of mahogany, I always omit the filler, shellacing direct on the stain, as frequently chemical action takes place when oil is brought in direct contact with mahogany stain used on birch.

NOTE 23—This specification applies to the finishing of red or white mahogany, cherry, birch, walnut, rosewood, etc.

Frequently, in finishing mahogany or other woods stained with a water stain in imitation of mahogany or otherwise, after lightly sandpapering the stain, I apply a light coat of shellac directly on the stain, sandpaper lightly, then proceed with the filler and varnish as specified. White shellac should never be used on dark mahogany or mahogany stained, as it will in time bleach out white, showing a milky film under the varnish. I

also frequently omit both the shellac and filler, applying directly to the stain a coat of linseed oil reduced one half with turpentine containing a little dryer. After this has remained on for some time, wipe off carefully any oil that may remain on the surface; allow that which the wood has absorbed to get perfectly dry; then proceed with the varnishing as specified. In this latter case, four coats of varnish should be applied.

For white or bird's-eye maple, holly, satinwood, etc., eliminate the filler and stain, specify two coats of pure grain alcohol white shellac and three coats of an extra pale varnish designed for this class of work, rubbing and finishing as specified. In bringing oil into contact with these and similar woods, it has a tendency to darken, whereas the purpose is to keep them as light and natural as possible.

For Italian or French walnut, circassian walnut, and similar woods, where it is so important that the natural colors and shading be preserved, eliminate the filler, and apply as above two coats of pure grain alcohol white shellac and three coats of a light varnish, rubbing and finishing as specified.

Fine carved work should never be varnished and rubbed as specified. Specify stain if necessary to conform with balance of wood; apply one light coat of shellac and two thin coats of wax rubbed to a hard surface with stiff bristle brush. One medium or light coat of a good flat varnish in place of wax, will answer very nicely. The filler with the several coats of varnish will have a tendency to filling up and rounding the sharp edges, and clean cutting so desirable in good carvings.

Staining and Waxing of Hardwoods

Medium—Stain all work with an approved stain, color to be selected. Do necessary sandpapering, after which apply one coat of paste filler, colored to conform with stain. Thoroughly clean all surfaces, and apply one medium coat of shellac. Sandpaper lightly, and apply one good coat of an approved finishing wax, permitting it to stand until semi-hard; then to be thoroughly rubbed and polished to a hard surface. (See Note 24.)

First-Class—Coat all surfaces (specify location) with

one medium coat of clean water (this for oak only). When thoroughly dry, sandpaper to a perfectly smooth finish; after which stain uniformly and in best manner with an approved water stain, color to be selected. Sandpaper lightly, and fill with paste filler, colored to conform with stain. Apply one coat of pure grain alcohol shellac; sandpaper lightly; after which apply two coats of an approved finishing wax, giving three days between coats. Permit each coat to become semi-hard; then to be thoroughly rubbed and polished to a hard surface. (See Note 25.)

NOTE 24—This specification will apply to oak, ash, chestnut, mahogany, cherry, etc. If a finish with open wood pores is desired, eliminate the filling, but add one additional coat of wax.

NOTE 25—This specification applies to oak, ash, chestnut, red and white mahogany, cherry, black walnut, etc., and calls for splendid results. A water stain is mentioned, it being the best and most satisfactory in showing up to advantage the general beauty of the natural shadings and figure of the woods. In staining, it should be emphasized that it does not mean a covering up, but rather the bringing out. In oil stains, the coloring matter is largely composed of pigments of a different character; and, as a rule, they are permanent; but they have a strong tendency to cover up. Spirit stains are hard to apply, and the results unsatisfactory, the coloring matter very often being fugitive. Where it is possible to attain the color requirements by the use of a water stain—and their number is legion—I would recommend it above all other. All water stains raise the grain of the wood more or less; spirit stains, very little; and oil stains, practically none. In connection with the use of water stain, I specify an application of clear water to the oak wood directly (in my practice I find no harm to a good job of cabinet work accruing from its use), so that the surface particles may be raised; and then cut off with sandpaper, so that the application of the water stain has no tendency to farther raise the grain. When the water coating is not uséd, and the water stain is applied directly, it requires so much sandpapering

to recover again a smooth surface that much of the stain and its effects are removed by the sandpapering. The water coating is very frequently omitted on less important work. When oil and spirit stains are used, the water coat should be omitted; for other than oak wood, it may also be omitted in the use of the water stain.

Very frequently, to get desired results, I apply a light coat of shellac directly on top of stain, after which I proceed with the filling as specified. I also frequently eliminate the shellac coating from on top of filler, applying wax directly on filler. The results desired must regulate the procedure.

When an open-grain or pore effect is desired, omit the filler, but add one additional light coat of shellac. It is very essential in this class of work that the shellac be applied thin and even, showing no laps or brush marks. If a perfectly flat or dead finish is required, omit both filler and shellac coatings, waxing as specified directly on the stain, although I would recommend the one coat of shellac. If the natural colors of the woods are to be retained, omit the staining, and proceed as specified and observing above notes.

For white and bird's-eye maple, satinwood, holly, French, Italian, and Circassian walnut, or any other similar woods, when required to be finished showing their natural colors, eliminate the water coat, stain, and filler; specify two thin coats of pure grain alcohol white shellac evenly applied directly on the wood, without showing laps or brush marks, sandpapering thoroughly each coat; then proceed with waxing as specified. When well done, this will give splendid results. Frequently mahogany and other woods than those specified above are finished after this manner. It is not unusual in procuring results to eliminate the shellac coatings, waxing as specified directly on the raw wood. When stain is necessary, apply wax directly on same.

Often pleasing results can be obtained by using a first-class dead or flat varnish. For instance, if a perfectly dead finish is required on open-pore surfaces, after applying the stain, sandpaper and apply one thin coat of shellac; sandpaper lightly and apply one coat of a good flat or dead varnish; eliminate the waxing. To get a still flatter effect, eliminate the shellac also. This process is not recommended for durability, simply for its

effect, and should be used only on open-pore woods such as oak, where the broken effect of the wood surface destroys the varnish coating effect. In this, window sash and sills should be protected with a coat of good body varnish; when dry, the gloss can be removed by rubbing.

Finishing Pine Floors

Thoroughly cleanse and remove all surface imperfections; shellac one coat, and varnish two coats of a good varnish designed for this purpose. Each coat must be thoroughly dry before the application of another. All necessary care must be taken to protect this work from damage. (See Note 26.)

NOTE 26—This specification applies to white and yellow pine, also to maple. If this class of flooring is required to be stained, specify, instead of the shellac, floors to receive one coat consisting of 25 per cent linseed oil and 75 per cent turpentine; sandpaper and close up all imperfections. Apply one coat of stain consisting of 40 per cent linseed oil and 60 per cent turpentine, evenly brushed into the wood, color to be selected. Follow this with varnish as specified.

The so-called "liquid fillers"—that is, prepared fillers sometimes used to coat over the surface and permitted to remain there without rubbing off—should never be used, for the reason that they do not dry thoroughly throughout. Many of them also have a tendency to discolor the wood, especially when they begin to bleach out by reason of age, etc.

The object in going over this work with a very thin coating of oil and turpentine is, that, if you were to apply the stain directly to the wood, the result would be a clouded or mottled surface, owing to the natural characteristics of these different woods to absorb more in one spot or place than in another. Very little if any stain should be left on the surface. It should be absorbed uniformly by the wood, and be thoroughly dry before the application of the varnish coatings.

Where a dull finish is required, specify to be rubbed lightly with oil and pumice stone to a dull finish. A dull or flat varnish should never be used on floors.

Varnish Finish for Hardwood Floors

Thoroughly cleanse and remove all surface imperfections. Fill all woodwork with a good paste filler, cleaning thoroughly from surface. Stain if required. Shellac one coat, and varnish two coats of best varnish designed for floor use. Each coat must be thoroughly dry before the application of another. Care must be taken to protect floors from damage. (See Note 27.)

NOTE 27—Very frequently the color desired for these floors can be obtained by adding necessary coloring matter to the filler. The color of the shellac (white or orange) should be determined by the color required.

If a flat finish is desired, specify to be rubbed with oil and pumice stone to an even, dull surface. A dull rubbed surface does not show surface scratches or abrasions as readily as a bright varnish gloss. Under no consideration use a flat or "dead" varnish to procure this result.

For first-class results you may eliminate the shellac coating and substitute one additional coat of varnish. It is very essential for best results, that each coat be thoroughly dry before the application of another.

This style of finish is suitable for residences; but proper care must be exercised that it be not abused, for at best a varnished floor surface, from its very nature, is more or less fragile.

Wax Finishing of Hardwood Floors

Thoroughly cleanse and remove all surface imperfections. Fill all wood surface with one coat of best paste filler, thoroughly cleansing same when semi-dry, from surface. Stain if required. Apply one thin, even coat of pure grain alcohol shellac. Sandpaper lightly without showing laps, after which apply two coats of best "prepared floor wax," giving two or three days between coats. Each coat must be thoroughly rubbed to a hard, dry surface. Care must be taken to protect floors from damage. (See Note 28.)

NOTE 28—This specification applies to practically all

class of flooring woods, and produces splendid results as a wax finish, being easily cared for by the housekeeper simply going over the surface lightly with turpentine, removing any surface dirt or imperfections, after which repolish with one coat of wax as specified. Especial care of the floor should be observed in front of the different doorways, as that portion receives the greatest amount of wear.

The whole secret of the success in obtaining a thoroughly practical waxed floor finish, is the recognition of the necessity of using a known good "floor wax." Then thoroughly harden each coat with the friction caused by good, honest, hard rubbing.

This manner of finishing as specified, while it produces the best-appearing wax-finished floor, has that which oftentimes is an objection, it being quite "slippery." To remove in a large measure this objection, eliminate the coat of shellac from the specifications.

For dancing or ballroom floors, I would apply the two coats of wax directly to the floor. Of necessity, the wax must be good and the rubbing hard, allowing two days between coats.

WOOD PAVING BLOCKS

THE round, untreated white cedar block was very largely used for paving in Northern cities many years ago, but it developed so many defects that wood paving came very much into disrepute. Within the last few years, the introduction of sawed, rectangular creosoted blocks has given such excellent results that they are rapidly becoming a most popular pavement throughout the United States, and especially where traffic is heavy or where a clean and comparatively noiseless pavement is desired. A well-creosoted block does not decay; and, if set upon a solid concrete foundation with a good sand cushion, the wear, even under the heaviest traffic, is very little, because the ends of fibers which are exposed simply mat down and do not shatter as do stone or brick. It is estimated that there are more than ten million square yards of streets paved with wooden blocks in the United States, and the total is rapidly increasing. The wood most largely used, because of its general availability, is longleaf pine; but Norway pine and tamarack have also been used for some time with good results, and there is a strong disposition on the part of paving engineers to experiment with numerous other woods. So, doubtless, the list will be much extended.

ESSENTIALS FOR A GOOD PAVEMENT

The best method of laying a wood block pavement to withstand heavy traffic was so well set forth by R. S. Manley, at the last annual meeting of the American Wood Preservers Association, that we quote as follows:

A creosoted wood block pavement should show no evidences of wear for many years, if the proper materials are used, and if they are assembled in the proper way.

The correct depth of base or foundation varies with the soil conditions; but the materials forming this concrete foundation, and the methods of mixing, are in such common use as to be standard and easily secured.

We are interested principally in the construction placed on top of the concrete. The principal causes of defects of more or less serious nature, are: (1) irregular or uneven surface due (a) to careless laying, (b) to shifting of sand cushion, (c) to breaking or settling of concrete. (2) Expansion difficulties due to the entrance of water into the blocks either by way of the joints or from below.

The first (irregular or uneven surface) is death to any paving material, because a depression in the surface holds water, and repeated churnings of wagon wheels in the depression are bound to cause an enlargement and deepening of the depression.

To avoid (a), the concrete should be mixed quite wet, and finished smoothly with a flat wooden spreader, which gives a surface practically as even and uniform as could be obtained by templet. On this should be spread from one-half to one inch of clean sand, making the sand cushion conform to the contour of the finished street. On this, place the blocks quite closely together; roll thoroughly until a perfect surface with no inequalities has been obtained, and until the blocks are firmly in

place. It will require a great deal of rolling to accomplish this, but the end justifies the means. After this, fill all joints two-thirds full of hot bituminous filler of such melting point as is suited to climatic conditions; and spread a thin coating of sand thereon. The use of the bituminous filler is, in my estimation, the most important of all. It converts the street into an effective watershed which, without absorbing any of the water, directs it into storm sewers or other drainage paths. Should any water remain on the surface, the wind and the sun, both good evaporative agencies, will rapidly dissipate it.

Now you have an absolutely even surface waterproofed and converted into a watershed. This surface cannot be worn by traffic, because the pressure of wheels is even and regular, and there is no dropping or jolting of wheels entering and leaving low spots. The blocks are laid tightly together, so that there is no wearing at the joints. There can be no change in the sand cushion as long as the surface remains intact, a solid sheet, in fact, of wood block cemented together by the filler; and consequently the difficulty of shifting cushion is avoided. It is assumed that the concrete is sufficiently strong so that it will not break or settle. In planning the depth, any error should be on the side of too great, rather than too little depth.

Expansion difficulties are eliminated by the use of bituminous filler, for there can be no expansion without absorption of water, and no absorption of water when all rainfall is conducted quickly to drainage sewers. In addition to this, it must be remembered that with the bituminous filler each block is surrounded by an individual expansion joint.

The other way of constructing wood block surface which is sometimes recommended, is to provide a mixed sand and cement cushion and sand-filled joints or interstices. The sand and cement cushion does not give

the opportunity for absolutely smooth surface that the sand cushion gives, and is considerably more costly. The sand filler in the joints allows moisture to be absorbed in the pavement; and ultimately this moisture gets into the blocks, and trouble ensues. It is only on extremely heavy traffic streets that sand can be used as a filler without expecting some expansion difficulties sooner or later. The proof of the pudding is the eating; and the proof of theories of wood block construction lie in the actual occurrences on the street.

It can be stated without fear of successful contradiction, that every sand-filled pavement in the South has at one time or other given trouble from uncompensated expansion; that with equal confidence it can be stated that not one bituminous-filled pavement has given trouble from this cause.

Now, there have been objections put forward to the bituminous filler because of the belief that it would produce a sticky surface, disagreeable in warm weather; but if the proper filler is secured, and it is correctly applied, there can be no such objection. The suitable filler has a consistency of rubber, and can be taken in the fingers, bent and twisted without soiling the fingers. In applying this filler, a spreader with squegee attachment places the filler in the joints where it is needed, and not on the surface of the blocks where it is not needed.

It is proper also to use less creosote oil per cubic foot of timber when bituminous filler is used, for the primary function of the creosote oil in this case is to preserve against decay, instead of trying to make the creosote oil fill the double role of preservative and absolute waterproofer. No one familiar with preservative methods and their history will question the efficacy of sixteen pounds of creosote oil per cubic foot in preserving against decay for an indefinite period. We therefore see that bituminous filler can be used carefully, and without inconvenience because of stickiness.

To sum up, therefore, provide adequate, smooth concrete foundation; use enough sand to cover any inequalities in the concrete or depth of blocks (except in railway areas and on grades, when use sand and cement mixed); lay blocks tightly; roll until smooth; fill joints with bituminous filler; spread coating of sand; and turn on traffic.

DEPTH OF PAVING BLOCKS

The proper depth of wooden paving blocks is a matter yet to be determined. Shallow blocks are likely to split because the pressure upon them under heavy traffic is so great that the fibers are pulled apart, or, as technically stated, the wood fails in longitudinal shear. Deeper blocks will not fail so easily; that is, a block three inches deep may soon give way under heavy traffic, while one four inches deep may stand up well.

Since longleaf pine has so far been regarded as the standard paving block wood, the Director of the Government Forest Products Laboratory recently made an interesting comparison of its longitudinal shearing strength with that of a number of other woods, and also indicated the depth it would be necessary to have blocks of these woods to give the same shearing strength as a longleaf pine block $3\frac{1}{2}$ inches deep. The results of the comparison are given in Table 13.

Of course, as the Director states, the depth of a block is not the only thing to be considered in wood pavement. Other conditions—such as

cost of material, and ability to take creosote—eliminate some of the woods listed in Table 13 from practical consideration for paving blocks.

TABLE 13

Longitudinal Shearing Strength of Wood Blocks

Species of Wood	Shearing Strength Parallel to Grain (Lbs. per sq. in.)	Depth Necessary to Equal Strength of Longleaf Pine (Inches)
Pignut hickory	2,710	2.18
Sugar maple	2,385	2.48
Rock elm	2,154	2.74
Beech	1,908	3.1
Red maple	1,789	3.3
Longleaf pine	**1,688**	**3.5**
Tupelo	1,577	3.75
Sycamore	1,554	3.8
Yellow birch	1,428	4.14
Tamarack	1,372	4.31
Western yellow pine	1,300	4.54
Norway pine	1,262	4.68
Douglas fir	1,180	5.01
Eastern hemlock	1,148	5.15
Shortleaf pine	1,135	5.2
White spruce	1,134	5.21
Lodgepole pine	974	6.07
Redwood	674	8.78

SPECIFICATIONS FOR WOOD BLOCK PAVING

The Association for Standardizing Paving Specifications has adopted the following specifications for paving with creosoted wood blocks:

Timber. The wood to be treated shall be Southern yellow pine, Norway pine, Douglas fir, or tamarack; but only one kind of wood shall be used in any one contract.

Yellow pine blocks shall be made from what is known as Southern yellow pine; and shall be well manufactured,

full size, saw-butted, all square edges, and free from all defects, such as checks, unsound, loose or hollow knots, knot-holes, worm-holes, through shakes, and round shakes that show on the surface. In yellow pine timber, the annular rings shall average not less than 7 to the inch, and shall in no case be less than 5 to the inch, measured radially from the heart so as to include the greatest number of rings possible.

Norway pine, Douglas fir, and tamarack blocks shall be cut from timber that is first-class in every respect, and shall be of the same grade as that defined for Southern yellow pine.

Size of Blocks. The blocks shall be from 5 to 10 inches long, but shall average 8 inches; they shall be from 3 to 4 inches in width; and they shall be 4 inches in depth.* The blocks used in any one street or improvement, however, shall be of uniform width; and there shall be always a difference between the width and depth of the blocks of not less than 1/4 inch.

A variation of 1/16 inch shall be allowed in the depth, and 1/8 inch in the width, of the blocks.

Treatment. The blocks shall be treated with the preservative under pressure, and shall at no time be subjected to a temperature of over 240 degrees F. They shall, after treatment, show satisfactory penetration of the preservative; and all blocks that have been warped, checked, or otherwise injured in the process of treatment, shall be rejected.

The blocks shall be treated with the preservative so that they shall contain not less than 18 pounds per cubic foot.

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* Note—The depth of the blocks may be reduced to 3½ inches in medium-traffic streets, and to 3 inches on light-traffic streets or alleys. The width and depth of the blocks, however, must never be equal. In case blocks 3 inches in depth are used, they shall not exceed 8 inches in length.

(Note—This amount may range from sixteen to twenty pounds, at the discretion of the Engineer, dependent on local conditions.)

Foundation. The base shall be of concrete made of the materials and in accordance with the methods prescribed in the specifications for cement and concrete adopted at the 1913 meeting, and shall be not less than 6 inches thick at all points.

(Note—The thickness of the concrete base may be reduced to 5 inches on light-traffic streets, and, in exceptional cases, to 4 inches, at the discretion of the Engineer.)

Sand Cushion. The blocks shall be laid on a cushion of clean, coarse sand 1 inch in thickness, which shall be struck to a surface parallel with the grade and contour of the finished pavement.

Mortar Cushion. Before placing the cushion, the surface of the concrete shall be cleaned and thoroughly dampened. A layer of sand and cement 1 inch in thickness, mixed dry in the proportion of 1 part Portland cement to 4 parts sand, shall be spread upon the concrete foundation, and struck to a surface parallel to the grade and contour of the finished pavement.

This cushion of sand and cement, unless previously moistened, shall be lightly sprinkled with water; and the blocks shall be immediately set thereon.

(Note—Under special conditions, particularly where vibration may be expected, the sand or mortar cushion may be omitted, and a bituminous coating, spread upon a smoothly finished and thoroughly dry concrete base, substituted therefor.)

Filler. When the blocks are laid upon the sand cushion, the joints between the blocks shall be filled with a suitable bituminous filler. When the blocks are laid upon a mortar or bituminous cushion, the joints may be filled with sand.

Expansion Joints. A longitudinal expansion joint not less than ¾ inch in width, and filled with a suitable bituminous filler, shall be placed along the curbs.

Redwoods in California

16—Lumber and Its Uses

The specifications for the creosote to be used are also defined very closely. The city engineer who follows throughout the standards set by the Association can be certain of a superior pavement of great durability.

HARDWOOD FLOORING

ONE of the most notable and useful developments of modern lumber manufacturing is the production of high-grade flooring of maple, beech, birch, oak, tupelo, yellow pine, Douglas fir, and other woods. This flooring is manufactured to exact standard sizes from selected, thoroughly seasoned stock, and is as carefully handled as is interior finish. In fact, a beautiful and durable hardwood floor is an important part of the inside finish of a building, now that carpets have been replaced by rugs.

Since hardwood flooring is manufactured from kiln-dried stock, is stored by the maker in dry sheds, and is shipped in closed cars so as to prevent the absorption of moisture, the user should make every effort to have the flooring carefully handled, correctly laid, and properly finished. Some of the points to bear in mind are to avoid unloading the flooring in damp weather; not to store it in open sheds or in newly plastered buildings; nor to lay it until the building is thoroughly dried out. When an under-floor is used, as is advisable with the thinner sizes, the hardwood flooring should be laid diagonally or across the sub-floor, and the latter should be dressed to even thickness.

The best practice indicates the use of steel

cut nails for hardwood flooring. These nails are manufactured especially for this purpose. They should be driven at an angle of 45 degrees; and it is stated that better results are obtained if no nails are placed within six inches of the end of the flooring pieces.

Maple, beech, and birch are close-grained woods of similar structure which give equally good appearance and service for flooring, whether slash- or quarter-sawed. Red and white oak floors are popular in both the plain and quartered forms, depending upon the figure desired; while quarter-sawed or edge-grain yellow pine and Douglas fir are very much better than slash-sawed floors of these woods. Strictly speaking, yellow pine and Douglas fir are softwoods, but edge-grain flooring made from them gives such good service that it is widely used for the same purposes as hardwood flooring.

MAPLE, BEECH, AND BIRCH FLOORING

The Maple Flooring Manufacturers Association has the following rules for maple, beech, and birch flooring:

Clear Grade

Clear—$\frac{13}{16}$ inch and thicker, shall have one face practically free of all defects, but the question of color shall not be considered. Standard lengths in all widths in this grade shall be trimmed 2 to 16 feet; the proportion of lengths 2 to $3\frac{1}{2}$ feet shall be what the stock will produce up to 15 per cent.

This grade combines appearance and durability and has a face free of defects that would materially mar the

appearance of the finished floor or impair its durability. It will be noted that the standard of appearance is that of a finished floor, not the top of a piano. A practical application of this rule will admit an occasional small sound pin knot not over $\frac{1}{8}$ inch in diameter; dark green or black spots or streaks not over $\frac{1}{4}$ inch wide and 3 inches long or its equivalent; birdeyes and small burls; a slightly torn grain or similar defect which can be readily removed by the ordinary method of smoothing the floor when it is laid; a slightly shallow place not over 12 inches long on under side of flooring if it does not extend to either end of the piece. An otherwise perfect tongue which is one-half short for 25% of length of piece is admissible; but the face must be free of checks or shake, and the wood must be live and sound.

No. 1 Grade

No. 1—$\frac{13}{16}$ inch and thicker, will admit of tight, sound knots and slight imperfections in dressing, but must lay without waste. Standard lengths in all widths in this grade shall be trimmed $1\frac{1}{2}$ to 16 feet; the proportion of lengths $1\frac{1}{2}$ to $3\frac{1}{2}$ feet shall be what the stock will produce up to 30 per cent.

This grade is made for service rather than appearance. It admits of tight, sound knots; prominent discolorations; numerous dark green or black spots or streaks; slight checks not exceeding 3 inches in length and running parallel with and well inside of the edges of the strip; dark spots or streaks with slight checks in center; small rough spots which cannot be wholly removed by the ordinary method of smoothing the floor when it is laid; slightly torn edges; short tongue if sufficient to hold properly in the floor; shallow or waney back if piece has sufficient bearings of full thickness to support it in floor; and slight variation in angle of end matching. While these and similar features are admissible, sufficient attention is given to appearance to make this grade desirable and satisfactory for use in stores, schoolhouses, and similar places where a waxed or varnished floor is not required.

Factory Grade

Factory—$\frac{13}{16}$ inch and thicker, must be of such character as will lay and give a good serviceable floor, with

some cutting. Standard lengths in all widths in this grade shall be trimmed 1 to 16 feet; the proportion of lengths 1 to 3½ feet shall be what the stock will produce up to 50 per cent.

This grade is suitable for factory, warehouse and kindred uses, and where a low-priced floor is wanted for wear, nothing better or cheaper can be obtained than the Factory grade.

Special Grades

White Clear is special stock manufactured from white clear maple lumber from the outside of the log, winter-sawed, and end-piled in sheds to prevent staining; is almost ivory white; and is the finest grade of Maple flooring it is possible to produce.

Red Clear Beech and **Red Clear Birch** are manufactured from all-red face stock, especially selected for color, and are free from all defects. The color is a rich, warm tint peculiar to no other wood.

The standard sizes for maple, beech, and birch flooring are indicated in Table 14.

TABLE 14

Standard Sizes for Maple, Beech, and Birch Flooring

Standard Thickness	Faces	Grades
13/16″	1½″, 2″, 2¼″, 3¼″	Clear, No. 1, Factory
Special Thicknesses		
1 1/16″, 1 5/16″, 1 11/16″,	2″, 2¼″, 3¼″	Clear, No. 1, Factory
⅜″	⅞″, 1″, 1½″, 2″, 2¼″	Clear and No. 1 only
½″, 5/16″	1½″, 2″, 2¼″	Clear and No. 1 only

⅝″ and thicker, all Faces, is measured ¾″ waste for matching.
½″ and thinner, all Faces, is measured ½″ waste for matching.

The Association makes the following recommendation for the use of the different grades:

Clear, or first quality, is suitable for apartment buildings, churches, clubs, dancing floors, gymnasiums, hospitals, hotels, office buildings, public buildings, residences, roller-skating

rinks, schoolhouses, stores, and similar buildings.

No. 1, or second quality, is a common grade, and its relation to Clear is similar to that between second and first grade of finish. It is just as serviceable as Clear, and equally as desirable when there is no objection to the appearance; and it can be used in the same class of buildings as the Clear grade, at a material saving in the cost of construction.

Factory, or third grade, will give excellent satisfaction in factories, creameries, granaries, mills, warehouses, workshops, and in other buildings, at mines, on farms, etc. Where a low-priced floor is wanted for wear, nothing better or cheaper can be obtained than this grade.

Laying and Finishing Hardwood Floors

One of the largest manufacturers of maple, beech, and birch flooring gives these directions for the laying and finishing of his products:

To get the best results, hardwood floors should be laid when the building is thoroughly dry, and in as dry weather as possible. Care should be taken that the surface upon which the floor is laid is clean and smooth. Drive the flooring up well, both side and end, being careful not to break the tongue.

Nail $\frac{13}{16}$-inch thick flooring with an eight-penny flooring brad. For $\frac{3}{8}$-inch thick flooring, a $1\frac{1}{4}$-inch finishing brad No. 15 is recommended.

Maple flooring for ordinary purposes should be left as it comes from the factory. Even for kitchen floors it is not well to fill it, for the oil tends to make it look dirty and greasy. If, however, a finish on a maple floor is desired, omit the filler. By doing this, the natural color of the wood is preserved.

After being laid, if it is needed, scrape until perfectly smooth. If a wax finish is desired, apply two light coats of wood alcohol shellac. Let the first coat stand one hour before putting on the second. When the second coat stands about two hours, sandpaper with No. O sandpaper, and the floor is ready for the wax, an article made expressly for this purpose and ready for use. Put on this wax as thin as possible, and let it stand half an hour. Then, with a weighted brush (made especially for the purpose), brush first across the grain of the wood, and again lengthwise, until the brush slips easily over the floor. When this result is effected, place a piece of soft carpet under the brush and rub until the desired polish is derived. This finish, when complete, is very desirable, but it requires quite an amount of labor to keep properly. When there are many and large rooms and sufficient help to do the work, it is doubtless the best.

To those, however, whose dwellings are not large and spacious and who desire a modern floor, we recommend the following as a convenient and durable finish: Apply two coats of good floor varnish, and the floor is complete. Should the gloss, which is the result of a varnish finish, be not desirable, rub the floor with a good rubbing oil and pumice stone, with a piece of burlap, lightly; wipe dry, and the gloss will disappear. The last coat of varnish should stand 48 hours before rubbing.

Floors that have been finished in shellac should be kept clean by thoroughly brushing off the dust with a soft hair or feather brush, or by wiping with a cloth of soft texture. If the cloth is slightly moist, the dust will adhere to it more readily, but wipe with a dry cloth afterward. If any dirt that will not wipe off with a moist cloth should be deposited on the floor, wash it off thoroughly with clean, warm water (not hot), using soap, if necessary, which also cleanse off with water as quickly as possible, and wipe dry.

When the face of the floor begins to look worn and shabby, after cleansing off the dirt and wiping dry, if water has been used, rub the surface all over nicely with a mixture two-thirds turpentine and one-third raw linseed oil. To do this, saturate a soft cloth of any kind with the mixture, wring out half-dry, and rub the floor with it evenly. Do not use the oil so freely as to leave it standing on the surface to catch dust. To prevent this, wipe off with a clean, dry cloth. After the shellac is worn down to the surface of the wood, sandpaper it all over evenly with a No. 1 sandpaper, and give it another coat of shellac, after which continue to keep as before.

Floors finished in a plain oil only, should be kept in the same manner as above, more soap and water being required and more frequent rubbing with the mixture of turpentine and linseed oil spoken of above.

Waxed floors can be cleansed by washing off thoroughly with turpentine and benzine, after which they can be re-waxed if desired.

Floors finished in "hard oil" should be kept like floors finished with shellac. A maple floor for a kitchen that has not been finished in wax or oil, is best taken care of by being scrubbed or rubbed with any of the scouring preparations now in the market for that purpose.

Every prospective user of maple, beech, and birch flooring will find it to his advantage to write to the Maple Flooring Manufacturers Association, Chicago, Ill., for a copy of the "Official Maple Flooring Book."

OAK FLOORING

The Oak Floor Manufacturers Association, whose office is in Detroit, Mich., distributes an

excellent booklet upon oak flooring, from which the following information is taken:

GRADING RULES

Quarter-Sawed Oak Flooring

Clear—Shall have one face practically free of defects, except 3/8 of an inch of bright sap; the question of color shall not be considered; lengths in this grade to be 2 feet and up, not to exceed 15 per cent under 4 feet.

Sap Clear—Shall have one face practically free of defects, but will admit unlimited bright sap. The question of color shall not be considered. Lengths in this grade to be 1 foot and up.

Select—May contain bright sap, and will admit pin-worm holes, slight imperfections in dressing, or a small tight knot, not to exceed 1 to every 3 feet in length; lengths to be 1 foot and up.

Plain-Sawed Oak Flooring

Clear—Shall have one face practically free from defects, except 3/8 of an inch of bright sap; the question of color shall not be considered; lengths in this grade to be 2 feet and up, not to exceed 15 per cent under 4 feet.

Select—May contain bright sap, and will admit pin-worm holes, slight imperfections in dressing, or a small, tight knot, not to exceed 1 to every 3 feet in length; lengths to be 1 foot and up.

No. 1 Common—Shall be of such nature as will make and lay a sound floor without cutting. Lengths 1 foot and up.

Factory—May contain every character of defects, but will lay a serviceable floor with some cutting. Lengths 1 foot and up.

Standard Thicknesses and Widths of Oak Flooring

13/16-inch thickness; widths 1½-inch face and 2¼-inch face.

⅜-inch thickness; widths 1½-inch face and 2-inch face.

The 1½-inch face makes a better, more serviceable, and handsomer floor than any other width. The shading of the figure of the wood may be blended more harmoniously than when the wider strips are used. The laying waste in the 13/16x1½-inch face is less than 2-inch face, as it is counted ½ inch for the tongue and groove; whereas, in the broader widths, it is counted ¾ inch. The cost per thousand feet is less than in the wider widths, which offsets additional cost for labor in laying.

The 2-inch and 2¼-inch faces are the widths more generally used in 13/16-inch thickness; and in ⅜-inch thickness, either 1½-inch or 2-inch face, as conditions demand it.

Use of Different Grades of Oak Flooring

Clear, Quarter-Sawed, Red or White—High-class residences, hotels, apartment houses, and club houses.

Sap Clear, Select; Quartered, Red or White—An economical substitute for Clear Quartered where a dark finish is desired. These grades make a flooring equally as durable as the first grade.

Clear, Plain-Sawed, Red or White—High-class residences, hotels, apartment houses, churches, and club houses.

Select Plain-Sawed, Red or White—Medium-priced residences, hotels and apartments; schools, office buildings, and stores.

No. 1 Common—Cheap dwellings, tenements, stores, high-class factories and manufacturers' buildings.

Factory—Warehouses, factories, and cheap tenements.

How to Determine Amount of Flooring Required

To cover a certain space, figure the number of square feet, which means the width multiplied by the length; for instance, a room 12 feet wide by 15 feet long would contain 12x15=180 square feet. Add to the square feet of surface to be covered, the following percentages:

33 1/3%	for	$\frac{13}{16}$ x 1½	inch
37 1/2%	for	$\frac{13}{16}$ x 2	inch
33 1/3%	for	$\frac{13}{16}$ x 2¼	inch
33 1/3%	for	⅜ x 1½	inch
25%	for	⅜ x 2	inch

The above figures are based on laying flooring straight across the room. Where there are bay windows, hearths, and other projections, allowance should be made for excessive cutting.

Laying Oak Floors

The laying of oak flooring is not very difficult. Any first-class carpenter can make a good job. Some judgment and care is very necessary in order to produce the best results.

A sub-floor should be used under both the $\frac{13}{16}$-inch and ⅜-inch thicknesses. The sub-floor should be reasonably dry and laid diagonally. Boards about 6 inches wide are preferred. These boards should not be put down too tight, and should be thoroughly dried off and cleaned before the oak flooring is laid.

It is well to use a damp-proof paper between the oak flooring and the sub-floor. Where sound-proof results are desired, a heavy deadening felt is recommended.

Oak flooring should be laid at an angle to the sub-floor. After laying and nailing three or four pieces, use a short piece of hardwood 2x4 placed against the tongue, and drive it up.

The nailing of oak flooring is very important. All tongued-and-grooved oak flooring should be blind-nailed. The best floor made can be spoiled by the use of improper nails. The steel cut variety is recommended for all blind-nailing.

For $\frac{13}{16}$-inch use 8 penny steel cut flooring nail.

For ⅜-inch, use 3 penny wire finishing nail.

The maximum distance between the nails should be:

For $\frac{13}{16}$-inch thickness, 16 inches.

For ⅜-inch thickness, 10 inches.

For even better results, it is recommended that the nails be driven closer than indicated.

Scraping Oak Floors

After the oak flooring is laid and thoroughly swept, it is better to scrape it, in order to get the best results for a nicely polished surface. This scraping process can be done by the ordinary scrapers, such as used by cabinet-makers, or by one of the many types of power or hand scraping machines that are generally used by contractors and carpenters. Always scrape lengthwise of the wood, and not across the grain. A floor properly scraped looks very smooth, but it should be thoroughly gone over with No. 1½ sandpaper to obtain the best results in finishing. After this, the floor should be swept clean, and the dust removed with a soft cloth. The floor is now ready for the finish.

Finishing Oak Floors

The finishing of an oak floor is a very important feature, upon which authorities fail to agree; but the question resolves into a matter of cost, as to the color or brilliancy of finish desired. Personal taste and artistic or decorative effects are the guide for the floor finisher.

The "Clear" grade of oak flooring should have a natural oak filler—color of oak. For the "Select" and "Sap Clear" grades, a light golden oak filler should be used; and, after the floor is filled, it should be gone over with a little burnt umber mixed with turpentine, to darken light streaks. This will make the "Select" and "Sap Clear" grades look like the "Clear" grade, except that it will be slightly darker in color. In filling the "No. 1 Common" grade, a dark golden oak filler should be employed; and the light streaks should be darkened in the same manner as the "Select" and "Sap Clear" grades. If a little care is used in laying this grade, splendid results can be obtained.

First, treat the floor with a paste filler of desired tone, to fill up the pores and crevices. To thin the filler for application, one has a choice of using turpentine, benzine, wood alcohol, or gasoline to get the right consistency. When the gloss has left the filler, rub off with excelsior or cloth, rubbing against the grain of the wood. This will make a perfectly smooth and level surface. It keeps out dirt and forms a good foundation, which is the keynote for successful treatment of floors. Allow the filler twelve hours to set or dry before applying a wax or varnish finish. Never use a liquid filler on any floor.

A wax or varnish finish can be used. The wax finish is preferred by many, due to economy and ease of renewing places that show the wear. The renewing can be easily applied by housekeeper or servant.

Wax Finish—The best method for applying the wax is to take cheesecloth, and double it to get a little more thickness; then make it into a sort of bag. Put a handful of wax inside of this, and go over the floor thoroughly. You will find that you can work the wax through the meshes of the cheesecloth to give an even coating over the floor. This prevents too much wax in spots and wasting it. After the floor has been gone over with the wax and allowed to dry say about twenty minutes, it is ready for polishing. Rub to a polish with a weighted floor brush, first across the grain of the wood, then with it. (A clean, soft cloth can be used in place of the brush if desired.) Then a piece of woolen felt or carpet should be placed under the brush to give the finishing gloss. After waiting an hour, a second coat of wax should be applied in the same way as the first, and rubbed to a polish.

Varnish Finish—This is usually more expensive than the wax finish; but it gives a very hard surface, yet at the same time it is elastic. Two or three coats should be applied after the application of the paste filler. Each

coat should be thoroughly rubbed with oil and pumice. Any of the standard hardwood flooring varnishes are recommended.

Floor Oil Finish—When a high-class finish is not desired, a very economical finish can be had by the use of a light flooring oil that is made expressly for this purpose by many paint and varnish houses and oil makers. It serves as a filler as well as a finish, and is strongly recommended for oak flooring in public institutions, office buildings and stores. This oil keeps the dust from rising and preserves the floor.

Care of Oak Floors

If one only knows how, nothing is easier than the care of a well-finished oak floor. Water should never be used on a waxed or varnished floor. The surface may safely be wiped with a cloth dampened in tepid water to remove dirt and dust; but the dampness should be immediately taken up with a dry cloth.

One of the best mixtures for keeping a floor in good condition is the use of equal parts of sweet oil, turpentine, and vinegar well mixed, and rubbed on the floor with waste or a cotton or woolen rag. The vinegar will cut the dirt or grime worked into the finish from shoes; the sweet oil produces a luster and the turpentine promptly dries the moisture.

The above mixture need not be applied oftener than once a month to insure a floor finish that will resemble the sheen of a piano.

Should wax finish become worn in spots from hard usage, a little of this mixture thoroughly rubbed will renew the finish quickly.

The occasional use of a weighted floor brush, alone or with a piece of Brussels carpet placed beneath it, will assist in keeping the finish of an oak floor in good condition.

Once a year, it is well to use a good floor wax, and

rub it into the floor with the aid of a brush, with or without a piece of carpet attached. Before the finish is worn down to the wood, an additional coat of wax should be applied and thoroughly rubbed.

Economical Use of Oak Flooring

As rugs are used almost universally in homes and offices, an economical plan is to have the center section of the room laid with oak flooring of a cheaper grade, and to employ the better grade in the border. After the rug is laid, all parts of the floor will have the same appearance. A room, say 10 by 12 feet, can have a 2-foot border of Clear (first quality), either Plain or Quartered; and in the center section 6x8-inch Select Plain could be employed. In a center section of this size, 15 per cent of the cost could be saved by using Select Plain. By using a little care in finishing up the Select, this grade can be made to look very much like the Clear grade. This makes quite a saving, and is being done very extensively.

Oak flooring of ⅜-inch thickness by 1½-ineh or 2-inch faces can be laid over old floors in old homes, or over cheap sub-floors in new homes very economically. It is cheaper than carpets, and will improve the appearance and sanitation of an old or new house more than the expenditure of double the amount of money any other way.

YELLOW PINE AND DOUGLAS FIR FLOORS

Edge-grain or quarter-sawed yellow pine and Douglas fir flooring are widely used for many of the same purposes as hardwood flooring. The Yellow Pine Manufacturers' Association recommends a hard oil finish for yellow pine floors in stores; a shellaced, varnished, and rubbed, or shellaced and rubbed finish for yellow pine

floors in apartments, residences, hospitals, etc.; and for bowling alleys and dance halls, several coats of varnish, rubbed and sanded between each coat, while sometimes the varnished surface is also waxed very lightly and rubbed down. For the treatment of yellow pine floors, the Association gives the following directions which are based upon the experience of many architects:

Finishing of Yellow Pine Floors

Never lay a yellow pine floor until the plastering in the building is on the wall and thoroughly dry. Yellow pine floors should be smoothed, hand-scraped, and sandpapered with the grain of the wood, and left in perfect condition to receive the work of the painter the same as any other hardwood floor.

To make a good finish, use only the best materials and skilled labor.

The close, hard fiber of Southern yellow pine renders a paste filler undesirable. Use the very best liquid wood filler; a thin shellac filler is more desirable however, although the cost is somewhat greater. Shellac requires several hours to dry perfectly.

The finishing coat for a varnished floor should be of the best elastic floor varnish.

Varnished and Polished Floor. Prepare a clean, smooth surface; and, if stain is required, apply a coat of the desired stain on the bare surface of the wood. Wipe off with cotton waste or cheesecloth to prevent raise of grain. Sand lightly with No. 0 sandpaper, and apply a thin coat of white shellac dissolved in grain alcohol; then sand again with fine sandpaper, and proceed with the finish in the regular way, by the application of floor varnish. To produce as fine a surface as

Nearly Pure Stand of White Ash

Contains some red oak and cherry

Plate 18—Lumber and Its Uses

Battery of Dry-Kilns Showing Truck-Loads of Lumber and Transfer Tracks

Plate 19—Lumber and Its Uses

on oak, each coat of floor varnish should be rubbed. Wax may be applied to the varnish surface if desired.

Dull or Waxed Floor. After a clean, smooth surface of the wood has been obtained, apply a coat of the desired stain (a neutral tint preferred). Wipe off with cotton waste or cheesecloth, to prevent the wood absorbing too much moisture. When the stain is thoroughly dry, seal the surface of the wood with a thin coat of white shellac. When dry, sand lightly with No. 0 sandpaper, apply second coat of thin shellac, and, when dry apply with a soft, dry cloth a generous coat of wax. Rub wax thoroughly into the surface with dry cloth or regular floor polisher.

The former way of waxing a floor omitted wood filler, shellac, or varnish, but included several coats of wax or oil thoroughly rubbed into the surface of the wood. The effect produced a polished but not a hard surface, and soon discolored from dust and dirt.

Hard Oil Floor. Properly clean and carefully smooth the floor surface; coat it over with boiling hot linseed oil, tinted such shade as will bring the sap and lighter shades to the heart color, allowing it to stand until thoroughly hardened before being exposed; give a second coat of the same materials, tinted as above mentioned; sandpaper, and finish with floor wax or first-class floor varnish. If wax is used, it must be thoroughly rubbed into the surface. If varnish is used, each coat should be carefully rubbed down.

Varnished Floor. Properly clean, scrape, and dust the floor surface insisting upon same attention as is given to hardwood. Apply one coat of good quality floor varnish; slightly cut with turpentine, allowing it to set 48 hours. When thoroughly dry, sandpaper lightly with No. 0 paper, and remove dust; apply second coat of the same good floor varnish, full strength, this in turn to stand until dry and hard; sandpaper lightly, and clean floor as before. Apply a third coat of varnish, full

strength; and either leave in gloss, or rub to a dull finish, as owner may direct.

The specifications for finishing yellow pine floors apply equally well to Douglas fir floors.

FIRE-RESISTANCE

THE fact that wood will burn if heated hot enough, has been the basis of a great hue and cry against wood by certain interests whose purposes would be better served were wood completely banished from all forms of construction. Just at present the agitation against the use of shingles in cities has gone so far that an individual whose main business is propaganda declares that a shingle roof is "not a covering but a crime." As a matter of fact, however, the records generally show that a larger proportion of fires in the United States are due to carelessness than to any one form or material of construction. Moreover, for many medium-sized factory buildings, what is called "standard mill construction" is more desirable than so-called "fireproof" construction. With proper safeguards, there is little danger from fire in mill-constructed buildings; and structures of this type have been known in a number of instances to stand up better under fire than have buildings of similar character with steel framework.

NATURAL FIRE-RESISTANCE

Not all woods are susceptible to fire in the same degree. Indeed, at the lower temperatures, there is a considerable range between

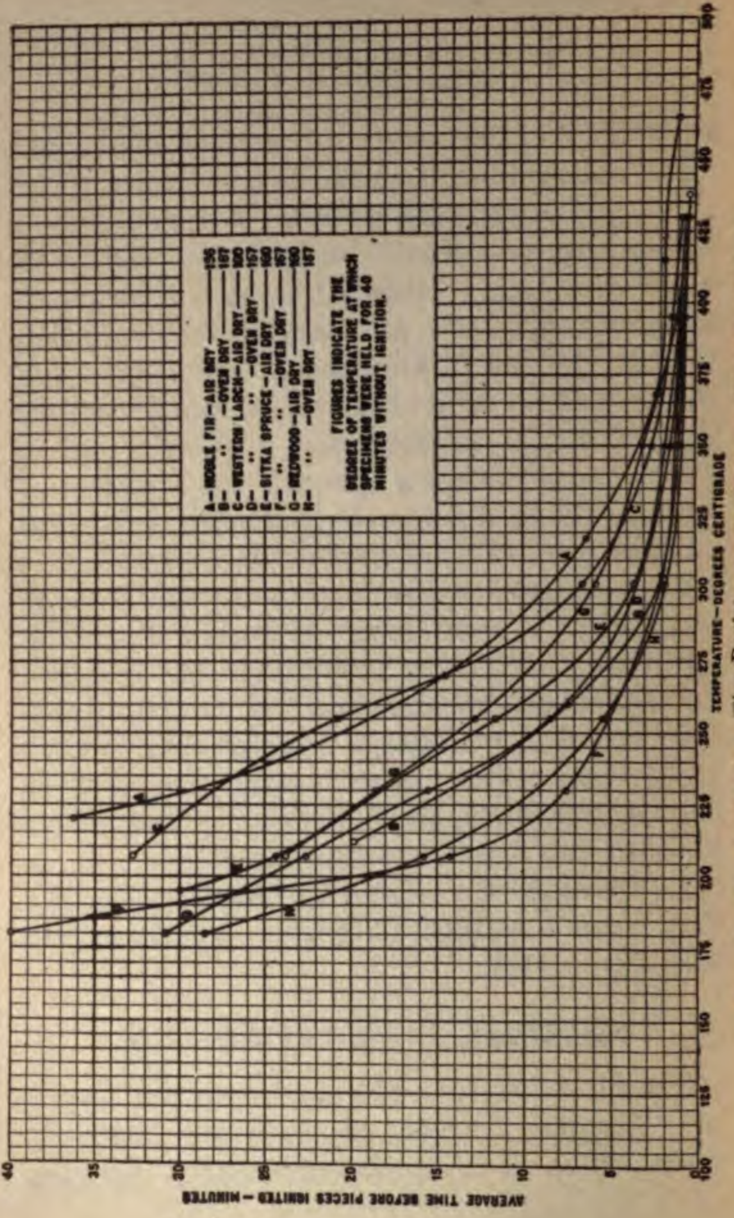


Fig. 9. Chart Showing Fire-Resistance of Various Western Woods

the different woods in the resistance which they offer to ignition. Still further, the ease with which wood burns depends upon its moisture content, a piece of dry wood catching fire, of course, much more quickly than a moist piece.

The United States Forest Service has recently concluded an interesting series of tests upon the natural fire-resistance of a number of species of timber. The results of these tests are shown graphically in charts on pages 148 and 150. It will be noted from these tests, that in the case of the Western woods, Western larch resisted ignition longest; and that among the Eastern woods, tamarack or Eastern larch held the same position. In fact, tamarack seems to be the most fire-resistant of eight woods tested. Curve A shows for example, that it was necessary to expose a piece of air-dry tamarack to a temperature above 205° C. (or 401° F.) for 40 minutes, in order to make it burn; while Curve F shows that a piece of oven-dry longleaf pine ignited in 15 minutes at a temperature of 175° C. (or 347° F.). On the other hand, air-dry tamarack and air-dry longleaf pine were both held at a temperature of 180° C. (or 356° F.) for 40 minutes, without ignition. When, however, the temperature became as great as 350° C. (or 662° F.), there was little difference in any of the species in resistance to ignition.

ARTIFICIAL FIRE-RESISTANCE

The attacks which have been made upon wood

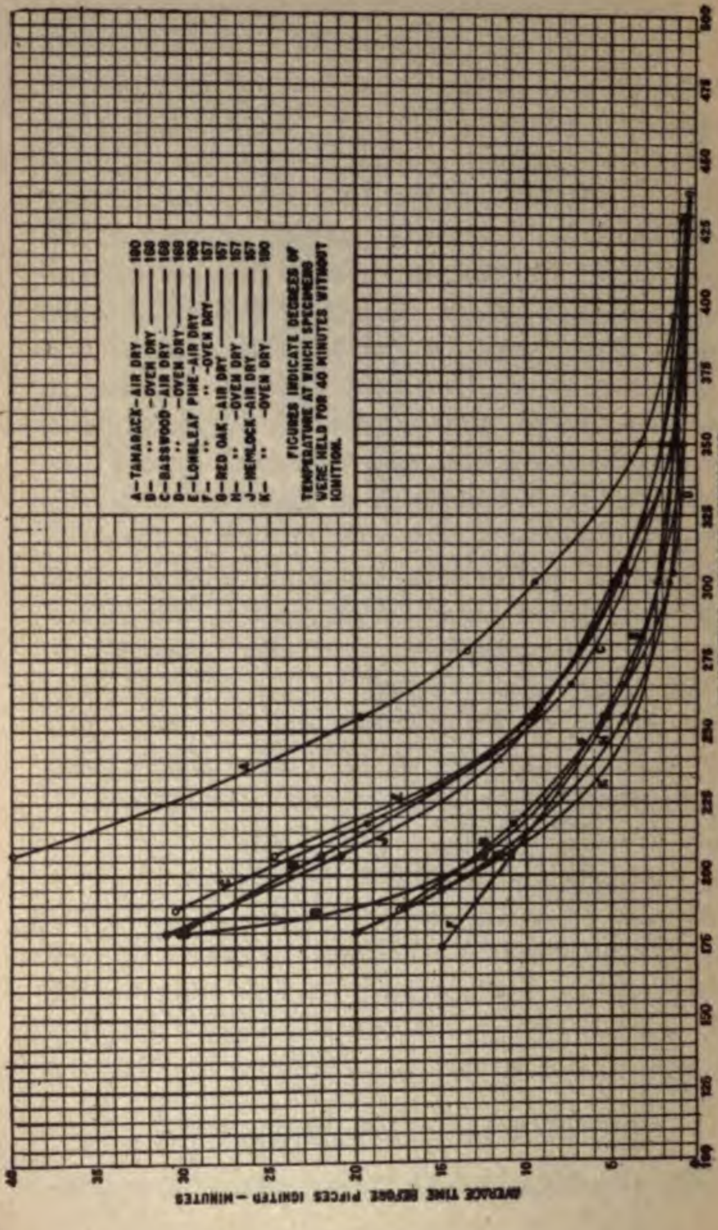


Fig. 10. Chart Showing Relative Fire-Resistance of Various Eastern Woods

as a building material, and the desire to increase its fire-resistance, have greatly stimulated studies to devise a cheap and effective means of fireproofing timber. It has been known, of course, for many years, that wood can be impregnated with salts which will make it practically incombustible; and such fireproofed wood has been used to a considerable extent for interior work for a long time. This, however, is quite different from the general fireproofing of shingles and of wood used in building exteriors where it is subject to all the action of the elements. It is not so much a question of the discovery of a fire-resisting material as it is the invention of processes by which large quantities of lumber can be quickly and cheaply fireproofed. Both private and governmental agencies are actively at work on the subject, and no doubt important results will soon be forthcoming.

The Forest Service experiments with chemical fire retardants have included tests of sodium carbonate, soda bicarbonate, oxalic acid, borax, and ammonium chloride. The first three did not prove efficient in retarding combustion, and they also weakened the wood. Borax has been found to have considerable value for fireproofing purposes, while wood thoroughly impregnated with ammonium salts could not be ignited under the Service conditions of test. The progress which has been made along this line as the result of only a short period of experimenta-

tion, leads the Forest Service engineers to the conclusion that it is possible to devise a reasonably inexpensive method of fireproofing wood, while firms already in the market claim that it is possible to do this on a commercial scale. It is not likely, therefore, that the opponents of wood construction will much longer be able to maintain that it is impossible to make wood resistant to fire where fireproof construction is necessary.

COMMERCIAL FIREPROOFING

The fireproofing of wood on a commercial scale is thus described by Mr. F. C. Schmitz, Vice-President of the Standard Wood Treating Company, New York, N. Y.:

The fireproofing of wood, as at present practiced commercially, is accomplished by saturating its fibers with a water solution of chemicals which, in the presence of fire, emit a gas that prevents combustion. To accomplish this, the wood to be treated is loaded on suitable cars, and placed in a cylinder from which the air is exhausted. The above-mentioned solution is then let into and completely fills the cylinder. Hydraulic pressure is then applied, by means of a pump, of such a degree and for sufficient time to force the chemical solution into and through the wood, to the point of saturation. Upon reaching this latter point, the cylinder is drained of solution, and the lumber removed.

When it is necessary that the treated lumber shall be thoroughly dry before it can be used, it is kiln-dried to evaporate the water in the solution, leaving the chemicals in the pores of the wood in dry crystal form.

It is not claimed for the product that it is fireproof in

the sense of being, like firebrick, indestructible in the presence of fire, but that it will not support or communicate combustion. Any organic substance will be destroyed by fire if left in its presence for a sufficient length of time.

An important fact in connection with the use of fireproof wood, is that it is fireproofed with water-soluble chemicals; and therefore, if, after treatment, it is exposed to water (such as rain), the chemicals again dissolve and are removed from the wood, with a consequent reduction in its resistance to fire. Any wood, therefore, intended for outside use, should be protected from the weather by a waterproof coating, such as paint or varnish.

Fireproof wood has been used largely for interior work, and principally in the city of New York, where the Building Code provides for its use in all buildings over 150 feet or twelve stories in height. It has, however, had a considerable use in residences and in various trades, for special purposes.

The treatment is permanent so long as no water is permitted to soak into the wood; and samples taken from buildings after fifteen years' service show as good results as freshly treated lumber. The treatment slightly hardens and in some cases darkens the wood. It does not, however, affect its strength or impair its beauty.

The process is comparatively inexpensive, when results are considered; and ultimately its use must be widespread, especially in isolated buildings where fire-fighting facilities are not of the best, and where fire would result in large damage to business.

Many corporations and firms in the East are now beginning to realize this point, and there is a constantly increasing demand for the product for such uses.

FIRE-RETARDANT PAINTS FOR SHINGLES

Under this title, Henry A. Gardner, Assistant

Director of the Institute of Industrial Research, Washington, D. C., discusses the latest results of his tests of fire-resistant paints as applied to shingles. In the first place, he calls attention to the low heat conductivity of a shingle roof in the following language:

"The writer conducted a series of laboratory tests to determine the heat deflecting properties of various types of roofing materials. Miniature houses were roofed with bare shingles, painted shingles, tin, and stone. Thermometers were inserted in the end of each house. The houses were placed in an oven heated to 150° C. At the end of 15 minutes, thermometric readings were taken. The interior of the houses roofed with stone and tin showed a much higher temperature than those roofed with shingles. The house with the roof covered with painted shingles showed the lowest temperature. On account of the heat deflecting properties of shingles, they will probably always find a wide application in warm climates. Shingled dwellings are much cooler in the summer than iron-clad or stone-roofed dwellings."

After mentioning the usual objections that are made to shingle roofs as sources of fire danger, Mr. Gardner continues:

"Although the writer has pointed out in the foregoing discussion, the many disadvantages of the wooden shingle, the situation is not as serious as it might at first appear. Very few structural materials have ever been made which have proved satisfactory for roofing or other building purposes, without some surface treatment. If iron or steel sheets are exposed to the weather, they will rapidly corrode and rust away to a mere lace-like skeleton of their original form. The application of suit-

able paint coatings at proper intervals, will, however, preserve such metal sheets for an indefinite period of time. Nearly all forms of cement or stone work will check, crack, absorb large quantities of moisture, and become unpleasing in appearance, unless properly treated with protective paints. The weather-boarding and wooden trim of all kinds of structures would soon rot and decay if left in an unpainted condition. It is evident that "paint is the preserver of all things structural," and that we must look to the use of paint for the solution of the problems under consideration.

Two Groups of Fire-Retarding Paints

"Fire-retarding paints may properly be divided into two groups, one of which is represented by oil-mineral paints, and the other by paints which do not contain oil. The term "mineral paint" refers to that type of paint which is so widely used throughout the rural districts to decorate and preserve dwellings, barns, and similar outbuildings. In the manufacture of these prepared mineral paints, various mineral pigments in a finely divided and carefully prepared form are ground in linseed oil, and mixed with the proper driers and thinners. The content of mineral pigment in such paints varies from 50 per cent to 70 per cent of the total. When such paints are applied to shingles, a very durable, waterproof film results. This film of dried paint upon the surface of a shingle has the effect of laying or smoothing down the rough, fuzzy surface of the wood, thus eliminating at once an important source of fire danger. The paint film, moreover, is quite as resistant to moisture as a sheet of India rubber. The shingled dwelling upon which such paint has been used is practically rain-proof. It is, moreover, made very attractive in appearance.

"Another important function is performed by the paint, in preventing the warping of shingles at the edge,

thus doing away with the formation of pockets in which hot cinders might lodge and burn.

"The fourth and most valuable characteristic of mineral paint is its resistance to fire. While the oil content is more or less combustible, there is present in the dried paint film a minor proportion of oil, the major proportion consisting of mineral pigments which are unaffected by fire. A hot cinder or spark, falling upon a roof properly treated with a high-grade mineral paint, would, in most instances, roll from the roof to the ground. There would be no pockets in which to lodge and burn. In the event of hot cinders falling with great force upon relatively flat roofs, the cinders would probably lodge upon the surface and burn away the superficial coating of dried oil, gradually dying out as they reached the fire-resisting mineral pigment.

"Prepared mineral paints of good grade may be obtained at a moderate price at any modern paint shop. They are, therefore, within the reach of anyone who desires to use them for protecting shingled structures. If made by a reputable manufacturer, the purchaser may be sure that they are prepared from properly selected mineral pigments, carefully mixed with oil, and finely ground, through rapidly revolving stone and steel mills, to a smooth condition. For coating shingles by dipping, such paints could be furnished in a thinner condition than for brushing. It is the writer's belief, however, that better results will be obtained if a heavy coat of paint is brushed upon the shingles, as in this case a greater amount of paint will become embedded within the surface of the wood, and the dried coating will contain a greater percentage of fire-resisting mineral.

Value of Impregnation Process

"It is obvious that the application of brush coats of any of the above named salts to wooden shingles would not result in the formation of weather-resisting surfaces.

It is the writer's belief, however, that a shingle manufacturer can at moderate cost impregnate shingles with certain mineral salts which will make them more resistant to fire. Wooden beams and railroad ties are often rendered more durable by treatment with preservatives possessed of fungicidal properties, such, for instance, as creosote or zinc chloride. These chemical substances are forced deeply into the wood by special processes. It would, in the writer's opinion, be practicable for the shingle manufacturer to adopt a similar process for mineralizing shingles. Mineral salts having a high resistance to fire could be used for the impregnation base. Shingles thus mineralized could be rendered still more resistant to fire by subsequently applying a coat of mineral paint. The writer has experimented with various salts for this purpose, and has treated shingles with their solutions, both by brushing and by dipping.

"Shingles thus treated have shown much greater resistance to fire. The best results were obtained by mineralizing the shingles and subsequently coating them with mineral paint. The mineralizing process of making the wooden shingle thoroughly safe as a roofing material should be carried out in two steps. The shingle manufacturer should undertake the first process of treating the shingle with fire-resisting salts. If shingles thus impregnated are furnished the builder, it is quite certain that he will carry out the second and most important part of the process, which consists in applying a decorative and waterproof coating of fire-resistant mineral paint. It will, of course, be possible to use the old-style creosote shingle stain over the mineralized shingle, in place of a mineral paint. However, the mineral paint will give much more satisfaction, as it forms a durable, waterproof film which is more resistant to fire than an ordinary stain."

Mr. Gardner outlines in detail methods for

making and testing fire-retardant paints, and concludes the discussion with these statements:

"The shingled roof is highly desirable on account of its durability, light weight, low cost, and non-conducting properties.

"Shingled roofs are subject to conflagration when they become dry. Hot cinders from chimneys or glowing sparks carried by the wind from nearby fires, are common causes of roof fires.

"The use of high-grade mineral paints upon shingled roofs eliminates such fire danger. Shingled structures of all types, when properly painted, are not only fire-resistant, but they are moisture-proof and highly ornamental.

"The painted shingle dwelling constitutes one of the most desirable types of modern suburban homes."

LUMBER PRICES

MANY well-informed people have the impression that lumber has become so scarce and high-priced that the ordinary man can no longer afford to build a wooden house. This impression, like the agitation against wood construction on account of fire risk, has been assiduously cultivated by the vendors of substitute materials. It is true that certain grades of some species of timber are high-priced, compared with the price at which the same grades could be obtained 20 to 30 years ago; but, on the other hand, there is still much good building material available for every purpose, at reasonable cost. While some kinds are scarcer than they once were, we are now using many valuable woods which were formerly wholly neglected. The last ten years has seen tremendous advances in the appreciation of red gum, beech, birch, maple, and the West Coast woods. While the highest grades of nearly all kinds of timber command high prices, because only a small amount of high-grade lumber is produced, we must remember that the ordinary structural materials consist of the medium grades, of which there is a much greater supply than of the higher grades. These medium grades have not had the same advance in price as the upper grades, owing both to their abun-

TABLE 15

Average Mill Prices of Principal Kinds of Lumber

(Per thousand feet, board measure)

KIND OF WOOD.	1912	1911	1910	1909	1908	1907	1906	1904	1899
All kinds	$15.35	$15.05	$15.30	$15.38	$15.37	$16.56	$16.54	$12.76	$11.13
SOFTWOODS.									
Yellow pine	14.36	13.87	13.29	12.69	12.66	14.02	15.02	9.96	8.46
Douglas fir	11.58	11.05	13.09	12.44	11.97	14.12	14.20	9.51	8.67
White pine	19.13	18.54	15.93	18.16	18.17	19.41	18.22	14.93	12.69
Hemlock	13.68	13.59	13.85	13.95	13.65	15.53	15.31	11.91	9.96
Western pine	13.62	13.58	14.26	15.39	15.03	15.67	14.01	11.30	9.70
Spruce	17.02	16.14	16.62	16.91	18.25	17.26	17.33	14.03	11.27
Cypress	20.09	20.54	20.51	20.46	21.30	22.12	21.94	17.60	13.22
Redwood	14.13	13.99	15.52	14.80	15.66	17.70	16.64	12.83	10.12
Cedar	14.45	13.86	15.53	19.95	18.03	19.14	18.12	14.35	10.91
Larch	11.96	11.87	11.85	12.39	11.81	13.07	11.91	8.94	8.00
White fir	9.86	10.64	11.52	13.10	11.38	15.45	12.91	(1)	(1)
Tamarack	(1)	(1)	11.30	13.18	12.86	15.71	15.63	12.42	12.43
Sugar pine	(1)	17.52	18.68	18.14	17.78	19.84	16.11	(1)	12.30
Balsam fir	(1)	13.42	14.48	13.99	14.36	16.16	(1)	(1)	(1)
Lodgepole pine	(1)	12.41	14.88	16.25	(1)	(1)	(1)	(1)	(1)
HARDWOODS.									
Oak	19.63	19.14	18.76	20.50	21.23	21.23	21.76	17.51	13.78
Maple	15.56	15.49	16.16	15.77	16.30	16.84	15.53	14.94	11.83
Tulip poplar	24.06	25.46	24.71	25.39	25.30	24.91	24.21	18.99	14.03
Red gum	12.60	12.11	12.26	13.20	13.08	14.10	13.46	10.87	9.63
Chestnut	16.62	16.63	16.23	16.12	16.27	17.04	17.49	13.78	13.87
Birch	17.42	16.61	17.37	16.96	16.42	17.37	17.24	15.44	12.60
Beech	13.51	14.09	14.34	13.25	13.50	14.30	14.06	(1)	(1)
Basswood	19.26	19.20	20.94	19.50	20.50	20.03	18.66	16.86	12.84
Hickory	23.29	22.47	26.55	30.80	29.66	29.50	30.42	23.94	18.78
Elm	16.67	17.13	18.67	17.52	18.40	18.45	18.06	14.45	11.47
Ash	20.27	21.21	22.47	24.44	25.51	25.01	24.35	18.77	15.64
Cottonwood	20.44	18.12	17.78	18.05	17.76	18.42	17.15	14.92	10.87
Tupelo	13.61	12.46	12.14	11.87	13.36	14.48	14.13	(1)	(1)
Sycamore	(1)	13.16	14.10	14.77	14.67	14.58	(1)	(1)	11.04
Walnut	(1)	31.70	34.91	42.79	42.53	43.31	42.25	45.64	36.49

(1) Not reported separately.

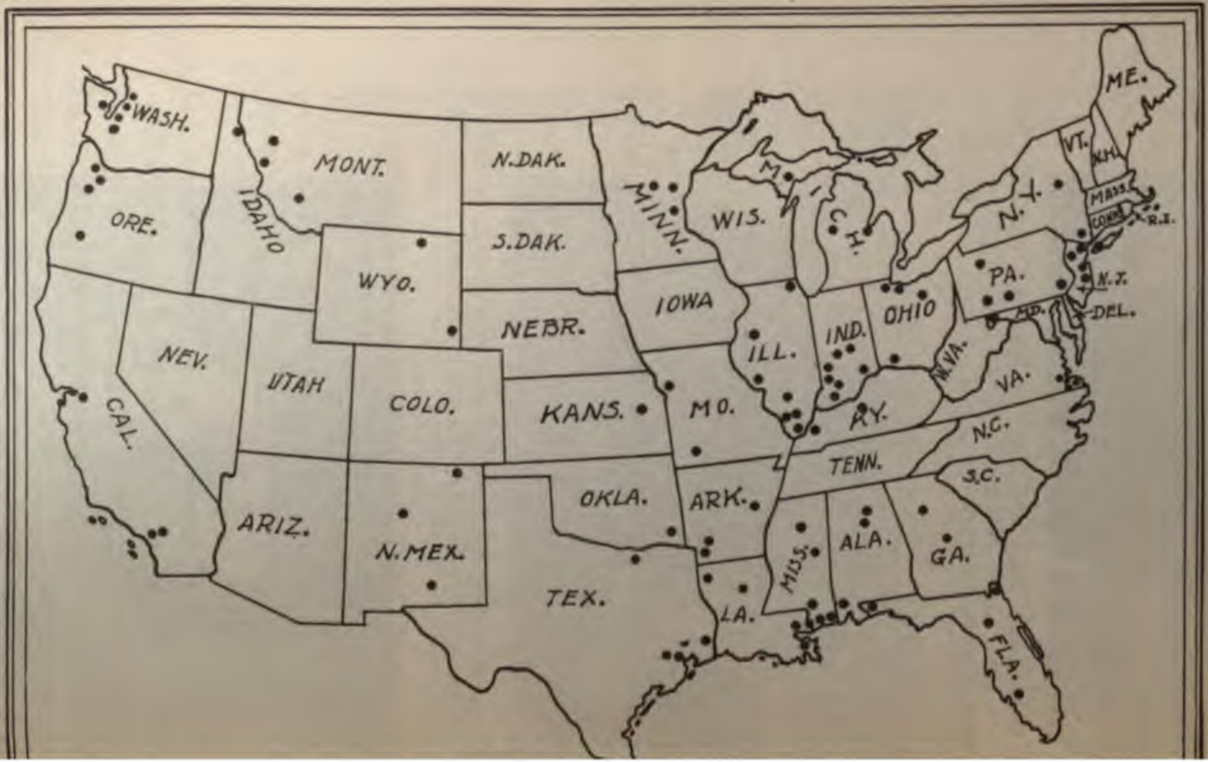
dance and to the competition of other materials. The same causes will prevent their advance to excessive prices for many years to come; hence these grades will continue for a long time to be the chief reliance of builders in many parts of the country.

That the price of lumber has not advanced more than that of many other commodities, and in fact, is scarcely as high now as it was several years ago, is shown by Table 15, which gives a tabulation, compiled by the Census Bureau and the Forest Service, of the average values per

House 150 years old, built of Southern Yellow Pine throughout, including siding, and still in a state of good preservation

House at Salem, Mass., sided with White Pine in 1684, and well preserved after 230 years

Old English Blockhouse on San Juan Island. Built in 1856. Roof of Western Red Cedar shingles still in good condition, after nearly 60 years' service without paint or repairs


WASH.
ORE.
CAL.
IDAHO
NEV.
MONT.
WYO.
UTAH
ARIZ.
COLO.
N.MEX.
N.DAK.
S.DAK.
NEBR.
KANS.
OKLA.
TEX.
MINN.
IOWA
MO.
ARK.
LA.
WIS.
ILL.
MICH.
IND.
OHIO
KY.
TENN.
MISS.
ALA.
GA.
FLA.
S.C.
N.C.
VA.
W.VA.
MD.
DEL.
N.J.
PA.
N.Y.
CONN.
R.I.
MASS.
VT.
N.H.
ME.

thousand feet at the sawmill, of the principal kinds of lumber.

The statement that lumber has reached such an exorbitant price that it can no longer be used,

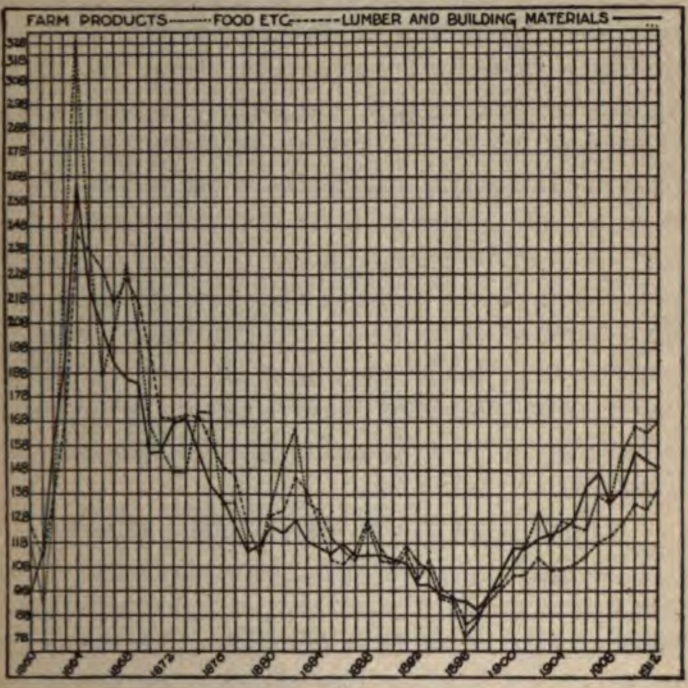


Fig. 11. Chart Showing Price Fluctuations of Lumber and Building Materials as Compared with Farm Products, Food, etc.

is best met by the records of the United States Bureau of Labor, the authority on the wholesale prices of all commodities. On page 149 of Bulletin 114 of the Bureau is given a table of the relative prices of nine groups of commodities from 1860 to 1912, the average price from 1890 to 1899 being taken as 100. The chart

(Fig. 11) shows in graphic form the record of the Bureau for three of the most important groups of commodities—farm products, food, and lumber and building materials. On the chart, farm products are indicated by a dotted line, food by a line of dashes, and lumber and building materials by a solid line. A single glance at the chart completely answers the statement as to the undue advance in lumber prices. On an average, these prices have run between the prices of farm products and of food for the last 50 years, and with neither as high points nor as low points as the two other groups. Still further, it will be noted that the prices of lumber and building materials are relatively lower now than they were 40 years ago; yet at that time no one thought that lumber was too expensive to build with.

COMPARATIVE BUILDING COSTS

Another way of approaching the same problem is through a comparison of the cost of wood construction with that of other materials; and here, again, lumber has nothing to fear. An article on this subject by Mr. H. W. Butterfield was recently published in "House and Garden." Plans were drawn for an average substantial house for a large family, to include all modern conveniences and to be built of first-class materials and of thorough construction. The plans and specifications were sent to architects in typical sections of the country, with a request that they submit cost figures for the house if

built of various materials in their localities. These estimates were carefully averaged and tabulated as follows:

Cost of a Typical House

New York City (suburban).....................$4,300.00

Per cubic foot, frame ....17 cents
Per cubic foot, brick ....21½ cents
Per cubic foot, stone ....22½ cents
Per cubic foot, stucco on metal lath............18 cents
Vicinity of Philadelphia, 10 per cent to 15 per cent less than near New York.

Maine $3,400.00

Per cubic foot, frame ....14 cents
Per cubic foot, brick ....17 cents
Per cubic foot, stone ....20 cents
Per cubic foot, stucco on metal lath............15 cents
In the southern New England States, the cost would be slightly in excess of the above.

Middle South (Kentucky, Maryland, etc.)..........$3,000.00

Per cubic foot, frame ....10 to 12 cents
Per cubic foot, brick ....12 to 14 cents
Per cubic foot, stone ....15 to 20 cents
Per cubic foot, stucco on metal lath.......11 to 14 cents

Chicago (Vicinity of).........................$3,800.00

Per cubic foot, frame...................15 to 16 cents
Per cubic foot, brick ....18 cents
Per cubic foot, stone.......................20 cents
Per cubic foot, stucco on metal lath.......16 to 17 cents

Middle Western States (such as Ohio, Michigan, Iowa, and Wisconsin) ....$2,550.00 to $4,000.00

Per cubic foot, frame ....10 to 12 cents
Per cubic foot, brick ....12½ to 20 cents
Per cubic foot, stone ....16 to 25 cents up
Per cubic foot, stucco on metal lath....12 to 18 cents up

Pacific Coast (Northwest)	**$2,000.00 to $3,200.00**
Per cubic foot, frame	8½ to 13 cents
Per cubic foot, brick	9½ to 14 cents
Per cubic foot, stone	14 to 16 cents
Per cubic foot, stucco on metal lath	9 to 14 cents
Colorado (average)	**$3,100.00 to $3,200.00**
Per cubic foot, frame	12 cents
Per cubic foot, brick	14 cents
Per cubic foot, stone	15 cents
Per cubic foot, stucco on metal lath	13 cents
Southwest (Arizona and New Mexico)	**$2,900.00 to $3,000.00**
Per cubic foot, frame	12 cents
Per cubic foot, brick	13½ to 14 cents
Per cubic foot, stone	16 cents
Per cubic foot, stucco on metal lath	13½ to 14 cents

Radford discusses the same problem on the basis of construction cost, per square yard of finished wall surface, of frame, of plain brick veneer, and solid brick construction, on the theory that the roof, foundations, floors, windows, interior finish, etc., are practically the same in each type, save that in brick construction the cost of stonework for sills, lintels, etc., must be added. His estimates for the cost of plain wall construction of the three types are as follows:

Frame Construction

(Per square yard of finished wall surface)

Dimension lumber, 8 ft. B. M., at 4c per ft. (in wall)	$0.32
Sheathing, 10 ft. B. M., at 4c per ft. (in wall)	.40
Siding, 12 ft. B. M., at 4½c per ft. (in wall)	.54
Building paper, put on, per yard	.03
Painting, two coats, per yd	.18
Plastering, three coats, per yd	.26
Total, per sq. yd	$1.73

Brick Veneer Construction

(Based on cost of face brick at $21.00 per 1,000)

Dimension lumber, 8 ft. B. M., at 4c per ft. (in wall)	$0.32
Sheathing, 10 ft. B. M., at 4c per ft. (in wall)	.40
Building paper, put on, per yd.	.03
63 face brick, at 3½c each (in wall)	2.21
Plastering, three coats, per yd.	.26
Total, per sq. yd.	$3.22

Solid Brick Construction

(12 in. wall)

63 face brick, at 3½c each (in wall)	$2.21
126 common brick, at $14 per 1,000 (in wall)	1.76
Furring walls, per yard	.06
Plastering, three coats, per yd.	.26
Total, per sq. yd.	$4.29

In conclusion, Radford states that, adding to each type of construction the cost of floors, doors, roofs, interior finish, etc., and dividing by the total number of square yards of wall surface, it is found that the cost of brick veneer construction is often 20 to 25 per cent greater than of frame construction, and that solid brick construction is about 40 per cent more expensive than frame construction.

It is often claimed that stucco on metal lath is now cheaper than lumber, for the exterior of houses. There may be cases in which the first costs compare favorably. It must be remembered, however, that stucco is not waterproof, that metal lath will rust sooner or later, and that this type of construction has not had a

long enough period of service behind it so that we can be at all sure of its permanence. The builder of wood can point to numberless instances of wooden siding on houses which has given good service for 50 years or more, and to many cases of durability of more than 100 years. So he does not begrudge the occasional coat of paint that the substitute advocate claims is not necessary for his own particular product.

THE USES OF LUMBER

FOR several years the United States Forest Service, in many cases with the assistance of State authorities, has been making studies of the more important wood-using industries, so that there are now available printed reports covering nearly every State in which there are large industries of this kind. These reports deal chiefly with the consumption of sawed lumber; but a few industries are included, in which raw material goes to the factory in log or bolt form. For such industries, the wood consumed has been reduced to board feet, to afford a proper basis for comparison with the requirements of other industries. Although both the total lumber consumption and the uses of the various species are unquestionably greater than is indicated by the available statistics, the figures presented are valuable for purposes of estimate and comparison.

Grouped in order of magnitude and stated in round numbers, it appears that the present annual wood consumption (chiefly in the form of lumber) for various special purposes, in the United States, is not less than the amount shown in Table 16.

1. General Building and Construction. Probably more than 40 per cent of the total lumber

TABLE 16

Annual Wood Consumption for Various Special Purposes

	Purpose	Million Board Feet
1.	General Building and Construction	19,000
2.	Planing Mill Products	15,000
3.	Boxes and Crates	4,600
4.	Furniture and Fixtures	1,400
5.	Car Construction	1,260
6.	Vehicles	740
7.	Woodenware, Novelties, etc.	400
8.	Agricultural Implements	320
9.	Handles	280
10.	Musical Instruments	260
11.	Tanks and Silos	225
12.	Ship and Boat Building	200
13.	Caskets and Coffins	150
14.	Refrigerators and Kitchen Cabinets	140
15.	Excelsior	100
16.	Matches and Toothpicks	85
17.	Laundry Appliances	80
18.	Shade and Map Rollers	79
19.	Paving Materials and Conduits	76
20.	Trunks and Valises	75
21.	Machine Construction	69
22.	Boot and Shoe Findings	66
23.	Picture Frames and Moldings	65
24.	Shuttles, Spools, and Bobbins	65
25.	Tobacco Boxes	63
26.	Sewing Machines	60
27.	Pumps and Wood Pipe	56
28.	Automobiles	37
29.	Pulleys and Conveyors	36
30.	Professional and Scientific Instruments	35
31.	Toys	29
32.	Sporting and Athletic Goods	25
33.	Patterns and Flasks	24
34.	Bungs and Faucets	21
35.	Plumbers' Woodwork	20
36.	Electrical Machinery and Apparatus	18
37.	Brushes	13
38.	Dowels	12
39.	Elevators	10

40.	Saddles and Harness	9
41.	Playground Equipment	9
42.	Insulator Pins and Brackets	9
43.	Butcher Blocks and Skewers	8
44.	Clocks	8
45.	Signs and Supplies	7
46.	Printing Materials	5
47.	Weighing Apparatus	5
48.	Whips, Canes, and Umbrella Sticks	5
49.	Brooms and Carpet-Sweepers	2
50.	Firearms	2
51.	Other and Minor Uses	37
	Total	45,300

production of the United States goes directly from the sawmill into general building and construction, without passage through an intermediate wood-working factory. This includes all ordinary lumber used for structural work, sheathing, roofing, fencing, etc. Almost every kind of wood is used to some extent for these purposes; but the chief building material is the softwoods, because they are more easily worked, lighter, and usually cheaper than the hardwoods in the grades suitable for building purposes.

2. Planing Mill Products. Planing mill products (flooring and finishing lumber, sash, doors, blinds, etc.) are closely connected with the use of general building material, and consist of almost every kind of native and foreign timber. The softwoods—especially yellow pine, Douglas fir, and white pine—are the principal woods used for sashes and doors, while almost every kind of hardwood is used for flooring and interior finish.

Among the more costly native and imported woods which are improved by mill work, are mahogany, black walnut, cherry, circassian walnut, padouk, prima vera, teak, ebony, sandalwood, Spanish cedar, rosewood, koa, and holly. Some of these are used chiefly for inlaid work, and others for panels. Altogether, the government reports indicate the use of more than 60 kinds of wood in the planing mills and sash and door factories of the United States. The States in which these factories are most largely operated are New York, Illinois, Wisconsin, Minnesota, and Michigan, although they are found to some extent in every State of the Union.

3. Boxes and Crates. The manufacture of boxes and crates consumes 10 per cent of the annual lumber output of the United States; and while no other industry can use a larger variety of woods, it is noteworthy that white pine and yellow pine supply 50 per cent of the box material.

Among the most desirable qualities in box-making woods are lightness, strength, nail-holding power, and a surface upon which names and descriptions can be easily printed. For this reason the softwoods and the softer hardwoods have always been in demand for box making. The lower grades of lumber are mostly used, since they are cheap and their defects can be cut out in the process of manufacture.

Virginia is the leading box-making State, with a consumption of more than 400 million

feet of lumber annually for this purpose. Illinois, New York, Massachusetts, and California are rather close competitors in the quantity of material used for box making. Next in order come Michigan, New Hampshire, and Ohio; and other States also are large producers of boxes.

The percentage of the total quantity of lumber used in the manufacture of boxes and crates, supplied by the leading species, is indicated in Table 17.

TABLE 17

Boxes and Crates

(Annual lumber consumption, 4,600 million board feet)

Woods Used	Per Cent
White Pine	25
Yellow Pine	25
Red Gum	9
Spruce	7
Western Pine	6
Cottonwood	5
Hemlock	4
Yellow Poplar	4
Maple	2
Birch	2
Basswood	2
Beech	2
Tupelo	2
Elm	1
Oak	1
Balsam Fir	1
Cypress	1
Other Woods	1
Total	100

4. Furniture and Fixtures. Next to box making, the manufacture of furniture and fixtures requires more lumber than any other industry,

[redacted]

although less than one-third as much as for boxes. The percentage of the total supplied by the more important woods is shown in Table 18.

TABLE 18

Furniture and Fixtures

(Annual lumber consumption, 1,400 million board feet)

Woods Used	Per Cent
Oak	38
Maple	11
Red Gum	8
Birch	7
Yellow Poplar	5
Chestnut	4
Beech	4
Elm	3
Basswood	3
Yellow Pine	2
Mahogany	2
Others	13
Total	100

Because of its beautiful figure, hardness, wearing qualities, and susceptibility to finishes and polish, oak has always been a leading furniture wood. The strength and hardness of maple likewise place it high as a furniture wood; while the figure, color, and receptivity to stains give red gum and birch a large field of usefulness in furniture making. Many beautiful and rare imported woods from all quarters of the earth are also used to secure especially rich and decorative effects.

A large number of woods are used in furniture making which do not appear in the finished

article. These are for backing, lining, and interior reinforcement to give strength and to furnish the foundation for the more expensive woods, which are generally used as veneer in order to reduce cost or to get better effects than are possible with solid stock.

At present, North Carolina is the largest furniture and fixture producing State in the Union. Next in importance ranks Illinois, closely followed by New York, Michigan, Wisconsin, Indiana, and Pennsylvania.

5. **Car Construction.** Some forty kinds of wood are used in the construction of freight, passenger, parlor, sleeping, and dining cars; but over half the total quantity is supplied by yellow pine, and nearly one-fourth by oak. Yellow pine, oak, and Douglas fir are used where great strength is required for sills, brake-beams, posts, bolsters, plates, etc. Yellow pine, Douglas fir, Norway pine, and cypress are used for car siding, roofing, and similar purposes; yellow poplar, for panels; and ash, oak, red gum, mahogany, birch, cherry, walnut, and several imported woods, for inside finish.

There is such a wide variety of steam and electric cars for both freight and passenger purposes that the car-building ships furnish one of the best markets for many kinds of lumber. Illinois is far in the lead in car construction; Pennsylvania and Virginia are nearly equal; while much car-building is done in New York, Ohio, Indiana, and Missouri.

TABLE 19

Car Construction

(Annual lumber consumption, 1,260 million board feet)

Woods Used	Per Cent
Yellow Pine	54
Oak	24
Douglas Fir	7
White Pine	6
Yellow Poplar	3
Ash	1
Hemlock	1
Other Woods	4
Total	100

6. Vehicles. The making of vehicles and vehicle parts is an important industry in many of the Central and Eastern States. The more southerly States of the group, particularly Arkansas, Kentucky, and Tennessee, furnish the bulk of the raw material; while in Indiana, Ohio, Illinois, Wisconsin, Pennsylvania, New York, and Michigan, are located many large vehicle factories.

Many woods find some use in vehicle construction; but hickory and oak compete closely for the lead, and, taken together, supply over 60 per cent of the raw material. Hickory is used most largely for the spokes and rims of buggy wheels, for gear parts, and for felloes, hubs, axles, hounds, and bolsters. Wagon hubs are made of elm and birch; and—in addition to hickory and oak—hard maple, white ash, beech, and other hard, strong woods are used for gear parts. Yellow poplar has been much used for the bodies of carriages, delivery wagons, and

automobiles, since it can be obtained in large, clear sizes, works well, and takes paint and polishes easily. Wagon-box boards are largely made from cottonwood, red gum, basswood, and yellow poplar. Bottoms are made of longleaf and shortleaf pine, and also of maple, gum, and oak. Ash is used for frames; while osage orange is used for felloes, especially in the Southwest, where, under severe climatic conditions, the ordinary woods shrink too much.

The proportion of the total consumption of wood for vehicles, contributed by the more important species, is shown in Table 20.

TABLE 20

Vehicles

(Annual wood consumption, 740 million board feet)

Woods Used	Per Cent
Hickory	32
Oak	29
Yellow Poplar	7
Ash	6
Maple	5
Cottonwood	4
Elm	4
Yellow Pine	4
Red Gum	4
Birch	2
Other Woods	3
Total	100

7. Woodenware, Novelties, etc. The manufacture of woodenware, novelties, and similar articles requires more than 400 million feet of wood annually, of which ash, basswood, and

TABLE 21

Woodenware, Novelties, etc.

(Annual wood consumption, 400 million board feet)

Woods Used	Per Cent
Ash	15
Basswood	14
White Pine	12
Maple	9
Birch	7
Spruce	7
Chestnut	5
Yellow Pine	5
Elm	4
Beech	3
Cottonwood	3
Cypress	2
Red Gum	2
Oak	2
Yellow Pine	2
Cedar	2
Tupelo	1
Other Woods	5
Total	100

white pine supply nearly equal parts, with the balance contributed by over fifty other species.

Much of the material for woodenware goes to the factory in log form, without passing through the sawmill. Wooden pie and picnic plates, butter trays, and dishes are largely made from rotary cut maple, beech, and birch veneers. Many more substantial kinds of woodenware are turned on lathes, among which are dishes, bowls, platters, and trays made from basswood, cottonwood, and maple. Butter paddles and trays are made of ash and beech; and bread-boards, of basswood, cottonwood, white cedar, silver ma-

soted Cross-Arms Shortly after Removal from Treating Cylinder

Portable Plant of Cylinder Type for Creosote Treatment of Railroad Ties

te 22—Lumber and Its Uses

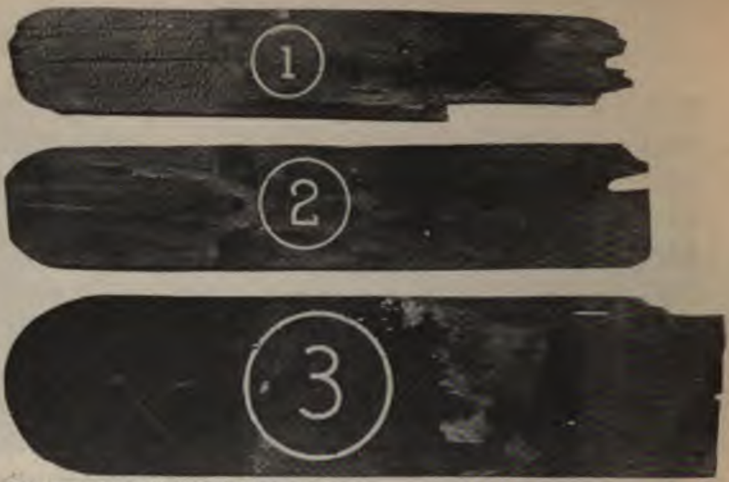


Photo by courtesy of Bolling Arthur Johnson

Cypress Shingles after Long Service on Washington's Home at Mount Vernon

All removed in 1913. No. 1—Laid in 1743, giving 170 years' service; No. 2—Laid in 1785, 85 years; and No. 3—Laid in 1860, 53 years.

Open-Tank Method of Creosote Treatment

Here applied to butts of chestnut poles

ple, and birch. Pails, buckets, and small tubs make up no small proportion of the woodenware output, and they often have white pine staves. Hoops for these articles are made from elm, ash, birch, and red oak. Peck, half-peck, bushel, and half-bushel measures are commonly made with bodies of oak, birch, maple, or white pine, and bottoms of white pine, basswood, or ash.

Novelties include wooden candlesticks, pin trays, paper weights, etc., and are frequently made of the higher-grade and more expensive native and imported woods.

Wisconsin produces the most woodenware of any State, with Michigan ranking second; while New Hampshire, Iowa, Vermont, and New York supply many articles of this class.

8. **Agricultural Implements.** Notwithstanding a greatly increased use of iron and steel in the manufacture of agricultural implements, such as plows, harrows, cultivators, drills, planters, threshing machines, rakes, and other articles, more than 300 million feet of lumber is annually used in this industry. Yellow pine supplies over 30 per cent of the lumber required for agricultural implements; oak, more than 20 per cent; and maple, 15 per cent, with relatively small quantities of cottonwood, red gum, ash, hickory, white pine, basswood, elm, beech, birch, and nearly twenty other species.

Longleaf pine is used in agricultural implements where strength but not necessarily toughness is required. Oak finds a large use for plow

beams and handles; beech, hickory, and oak, for neck-yokes and single trees; while cottonwood, yellow poplar, red gum, white elm, beech, tupelo, cypress, and Douglas fir are used for seeding and drill boxes. Douglas fir and longleaf pine are also used for poles and tongues of agricultural implements.

Illinois is by far the most important State in the manufacture of agricultural implements, while next in order are Ohio, New York, and Indiana.

TABLE 22

Agricultural Implements

(Annual lumber consumption, 320 million board feet)

Woods Used	Per Cent
Yellow Pine	31
Oak	22
Maple	15
Cottonwood	5
Red Gum	4
Ash	3
Hickory	3
White Pine	3
Basswood	2
Elm	2
Beech	2
Birch	1
Other Woods	7
Total	100

9. Handles. Handle manufacture is nearly as important as agricultural implement making in regard to the quantity of wood required; and hickory supplies more than two-fifths of all the handle material. Next to hickory, ash—espe-

cially white ash—furnishes some 23 per cent of the handle wood; and maple, 15 per cent; while beech, oak, and birch are important handle woods for certain purposes.

TABLE 23

Handles

(Annual wood consumption, 280 million board feet)

Woods Used	Per Cent
Hickory	43
Ash	23
Maple	15
Beech	6
Oak	4
Birch	4
Red Gum	2
Elm	1
Other Woods	2
Total	100

Hoe, rake, spade, shovel, and fork handles are chiefly made of ash; sledge and ax handles, of hickory; broom handles, most largely of maple, beech, and birch; cant-hook handles, of hickory and hard maple; pump handles, of oak, ash, and maple; and handles for wire stretchers, of white and rock elm.

Small handles for chisels, mallets, planes, awls, saws, etc., are often made from apple wood; while the handles for many small articles in which good appearance is desired are made from boxwood, walnut, mahogany, rosewood, and ebony.

Like the vehicle woods, much of the handle material is produced in the South, and worked up in the North. Arkansas and Kentucky sup-

ply large amounts of hickory for handles; while among the States in which handles are most largely manufactured are Michigan, Ohio, Missouri, Illinois, and Indiana.

10. Musical Instruments. The manufacture of musical instruments consumes a large amount of both native and foreign woods. Of the native woods, nearly equal quantities of maple, yellow poplar, and chestnut are used; while spruce, oak, elm, birch, basswood, white pine, and red gum are largely drawn upon.

The making of cases for pianos and organs requires a great deal of lumber, maple being used to give strength, yellow poplar and chestnut as the backing for veneer, spruce for sounding boards, the finer hardwoods and imported woods for the keys, red gum and maple for action parts, birch for key rails and hammers, and beech and elm for backs. Many woods are used to give a varied and beautiful effect in the smaller musical instruments. Spanish cedar is used for the necks of banjos, guitars, and mandolins; boxwood, for inlay work; mahogany, bird's-eye maple, rosewood, yellow poplar, birch, walnut, and oak, for drums; bird's-eye and curly maple, and rosewood, for harp boxes, etc.

Illinois uses more wood than any other State for the manufacture of musical instruments, and New York ranks second; while Massachusetts, New Jersey, and Michigan are large consumers of material for this purpose.

TABLE 24

Musical Instruments

(Annual lumber consumption, 260 million board feet)

Woods Used	Per Cent
Maple	17
Yellow Poplar	16
Chestnut	15
Spruce	11
Oak	8
Elm	6
Birch	5
Basswood	4
White Pine	3
Red Gum	3
Mahogany	3
Black Walnut	2
Beech	2
Ash	1
Other Woods	4
Total	100

11. Tanks and Silos. Wooden tanks and silos require straight-grained, easily-worked, durable material which can be obtained in good sizes and which will not impart any objectionable taste to the contents. The woods most largely used for these purposes are Douglas fir, yellow pine, cypress, white pine, spruce, redwood, and larch or tamarack. Douglas fir and yellow pine are used to a very large extent for silos, because of their abundance; while, to a lesser extent, silos are made from cypress, tamarack, redwood, and hemlock. Tanks and vats for holding oil, water, and distillery and brewery products are largely made from cypress and redwood. Oak is also used for distillery tanks.

In the manufacture of tanks and silos, Indiana has the leading place, followed closely by Illinois, Iowa, Michigan, and California. However, silos are not necessarily factory products, since material for them is often produced at sawmills and sold through lumber dealers in the localities where silos are erected. For this reason, the figures given in Table 25 are less than the total lumber consumption for tanks and silos.

TABLE 25

Tanks and Silos

(Annual lumber consumption, 225 million board feet)

Woods Used	Per Cent
Douglas Fir	40
Yellow Pine	18
Cypress	16
White Pine	8
Spruce	5
Larch	4
Redwood	4
Oak	2
Cedar	2
Other Woods	1
Total	100

12. Ship and Boat Building. The ship and boat industry in the United States annually consumes some 200 million feet of lumber, of which yellow pine supplies one-third, Douglas fir about one-fifth, and oak about one-sixth. Important woods in this industry are also white pine, ash, spruce, cedar, and cypress; while nearly forty other woods are used to a less extent, including such imported species as mahogany, teak, prima

vera, Spanish cedar, circassian walnut, balsam, lignum vitae, padouk, and rosewood.

TABLE 26

Ship and Boat Building

(Annual lumber consumption, 200 million board feet)

Woods Used	Per Cent
Yellow Pine	33
Douglas Fir	22
Oak	16
White Pine	7
Ash	4
Spruce	4
Cedar	4
Cypress	3
Hemlock	2
Other Woods	5
Total	100

Yellow pine and Douglas fir are the most important shipbuilding woods because of their strength and their availability in large structural sizes. Both longleaf pine and Douglas fir are used for spars, decking, keels, keel-blocks, rails, guards, and the like. Cypress, white pine, oak, yellow pine, and Douglas fir are also used for inside finish, as well as for ceiling and decking; while numerous hardwoods and imported woods are used for inside finish. Teak is used for armor backing; and balsa, or corkwood, for life preservers.

On the Pacific Coast, Douglas fir, Port Orford cedar, redwood, and Sitka spruce find a large use in ship and boat building; while in Maine and some of the Eastern States, the manufacture of high-grade pleasure canoes has as-

sumed large proportions, these canoes being often made with white cedar ribs, planking of Western red cedar, gunwales of spruce or mahogany, thwarts of birch or maple, and seats of birch, maple, or ash.

New York is the largest ship and boat building State, due to the Brooklyn Navy Yard. Pennsylvania takes second rank because of its large shipbuilding plants; while California, Oregon, New Jersey, and Maine are also large producers of ships and boats.

13. Caskets and Coffins. About 150 million feet of lumber are used annually in the manufacture of caskets and coffins, of which chestnut supplies 30 per cent, white pine 32 per cent, and cypress 13 per cent, the balance being made up by nearly thirty other woods.

Chestnut and white pine are most largely used in the manufacture of cloth-covered caskets and coffins. Chestnut is also much used as the backing for a veneer of more expensive woods of ornamental appearance. The exterior often consists of mahogany, yellow poplar, white oak, red oak, or birch. Cypress, cedar, and redwood are used because of their resistance to decay; while white pine, shortleaf pine, and yellow poplar are common woods for outer boxes and shipping cases.

In the manufacture of caskets and coffins, New York ranks first, followed by Pennsylvania, Tennessee, Ohio, and Illinois.

TABLE 27

Caskets and Coffins

(Annual lumber consumption, 150 million board feet)

Woods Used	Per Cent
Chestnut	30
White Pine	22
Cypress	13
Yellow Pine	8
Yellow Poplar	6
Oak	5
Red Gum	5
Cedar	4
Basswood	2
Hemlock	1
Other Woods	4
Total	100

14. Refrigerators and Kitchen Cabinets. Nearly 20 species of wood are used in the manufacture of refrigerators and kitchen cabinets; but oak supplies 23 per cent of the total, ash 14 per cent, and red gum 10 per cent. Other woods used to a considerable degree for this purpose are elm, white and yellow pine, hemlock, maple, yellow poplar, spruce, basswood, cottonwood, and birch.

Woods for refrigerators and kitchen cabinets must meet a wide variety of requirements. The outside finish must look well, and here the usual cabinet woods are employed. Strong, stiff material for frames is supplied by hemlock and shortleaf pine; elm and beech stand up well under dampness, and scour well when washed. It is also essential that, in certain places, woods shall be used which impart no odors to food;

for these purposes, elm, maple, basswood, cottonwood, and cypress are satisfactory. Iceboxes are often made of spruce, refrigerator backs of white pine, and ice cream freezers of redwood.

In the manufacture of refrigerators and kitchen cabinets, Michigan ranks first, and Indiana second, followed by New York, Wisconsin, and Indiana.

TABLE 28

Refrigerators and Kitchen Cabinets

(Annual lumber consumption, 140 million board feet)

Woods Used	Per Cent
Oak	23
Ash	14
Red Gum	10
Elm	9
White Pine	6
Yellow Pine	6
Hemlock	5
Maple	5
Yellow Poplar	4
Spruce	4
Basswood	4
Cottonwood	3
Birch	3
Cypress	1
Chestnut	1
Other Woods	2
Total	100

15. Excelsior. Excelsior finds a large use for packing, mattresses, and upholstering. It is made in a number of grades based on quality and fineness; and the best requires a wood which, in addition to working easily, gives a tough, flexible product. The finest grade—called

"wood wool"—has a strand less than 1/100 of an inch in thickness.

The true poplars, including the various aspens and cottonwoods, supply more than half of the excelsior manufactured in the United States. Basswood and yellow poplar give a product of similar character, while coarser grades are made from yellow pine and several other woods. Among the States in which excelsior is most largely produced, are New York, Virginia, Wisconsin, and New Hampshire.

TABLE 29

Excelsior

(Annual wood consumption, 100 million board feet)

Woods Used	Per Cent
Cottonwood	54
Yellow Pine	15
Basswood	14
Willow	4
Red Gum	3
Maple	3
White Pine	2
Yellow Poplar	2
Buckeye	1
Other Woods	2
Total	100

16. Matches and Toothpicks. Although put into one table in the statistical reports, matches and toothpicks are by no means made from the same woods. White pine has long been a standard match material, and basswood is used to some extent for this purpose in the Eastern factories. On the Pacific Coast, sugar pine and

Port Orford cedar are used for match sticks; while in Virginia yellow poplar and soft maple are also used. Spruce is employed for the making of match cases.

Toothpicks are made almost exclusively from birch and maple and are chiefly produced in Michigan and New England.

TABLE 30

Matches and Toothpicks

(Annual wood consumption, 85 million board feet)

Woods Used	Per Cent
White Pine	86
Basswood	7
Birch	4
Maple	1
Spruce	1
Other Woods	1
Total	100

17. Laundry Appliances. Laundry appliances include washing machines, washboards, ironing boards, clothes wringers, mangles, tubs, clothespins, and similar articles. Cypress and maple compete closely for the lead in the manufacture of laundry appliances, while nearly equal quantities of beech and cottonwood are required. More than twenty other woods contribute to the total of some 80 million feet of lumber annually consumed in this industry.

Cottonwood, basswood, and Sitka spruce are much used for washboards. Frames of ironing boards are often made of maple; and the tops, of cypress, cottonwood, spruce, basswood, and

white pine. Wooden mangles are usually made of elm, beech, or maple; and wooden tubs frequently have cypress staves. Laundry machine construction uses cypress, maple, basswood, yellow poplar, and red and white oak. Clothes-pins are most largely made of basswood, beech, and maple, and also to some extent of birch, elm, and ash.

In manufacture of laundry appliances, Michigan has a large lead, with Indiana, Iowa, New York, and Ohio ranking next in importance.

TABLE 31

Laundry Appliances

(Annual lumber consumption, 80 million board feet)

Woods Used	Per Cent
Cypress	19
Maple	18
Beech	12
Cottonwood	10
Basswood	6
Cedar	6
Birch	5
Tupelo	5
Red Gum	4
White Pine	4
Spruce	3
Yellow Pine	2
Elm	2
Hemlock	2
Other Woods	2
Total	100

18. Shade and Map Rollers. Nearly four-fifths of all the shade and map rollers are made from white pine; and one-seventh, from spruce

and other softwoods. Such hardwoods as are credited to this industry are used chiefly for curtain poles and trim.

TABLE 32

Shade and Map Rollers

(Annual lumber consumption, 79 million board feet)

Woods Used	Per Cent
White Pine	78
Spruce	9
Douglas Fir	4
Red Gum	3
Yellow Pine	1
Tupelo	1
Maple	1
Other Woods	3
Total	100

19. Paving Materials and Conduits. The manufacture of paving materials and conduits of wood which is given a chemical treatment to prevent decay, is one of the more recently developed industries; but it has already reached a considerable size, requiring about 76 million feet of lumber annually. As is brought out in the discussion of wood block pavements, yellow pine is by far the most largely used wood for this purpose; but larch or tamarack, Douglas fir, Norway pine, and tupelo are also used, the latter more especially for conduits to carry underground telegraph or telephone lines. These materials are prepared wherever creosoting plants may be located, of which there are now nearly 100 in the United States, as shown by the map in Plate 21.

TABLE 33

Paving Materials and Conduits

(Annual lumber consumption, 76 million board feet)

Woods Used	Per Cent
Yellow Pine	86
Larch	6
Douglas Fir	5
Tupelo	1
Other Woods	2
Total	100

20. Trunks and Valises. The manufacture of trunks and valises annually consumes about 75 million feet of twenty-four different woods, of which basswood supplies 28 per cent, yellow pine 20 per cent, and white pine 10 per cent.

Trunks and valises are usually made from softwoods which offer a desirable combination of light weight and strength, or from veneer of hardwoods, in which strength can be secured without much weight. Trunk slats are generally of maple, beech, or elm; and here strength is an important property. Trunk trays are largely made from basswood and yellow pine; while the box of the trunk is either of thin lumber with some kind of outside covering, or, in the better grades, of built-up veneer, which gives much strength and resistance to hard knocks.

Trunks and valises are largely made in Virginia, Michigan, Wisconsin, Pennsylvania, and Ohio.

TABLE 34

Trunks and Valises

(Annual lumber consumption, 75 million board feet)

Woods Used	Per Cent
Basswood	28
Yellow Pine	20
White Pine	10
Hemlock	9
Elm	9
Maple	7
Yellow Poplar	4
Cottonwood	3
Red Gum	2
Spruce	2
Cypress	2
Other Woods	4
Total	100

21. Machine Construction. Under this heading are grouped such machines as steam shovels, cranes, hoists, well drills, dredges, crushers, presses, etc., in which much of the wood used must possess strength, toughness, and durability. Yellow pine supplies one-third of the wood required for machine construction; cypress, 23 per cent; and oak, 12 per cent; while nearly thirty other woods are used in smaller amounts.

The manufacture of machinery of this character is scattered over a number of States, and not so centralized as are many other industries. Among the States in which machine construction attains considerable magnitude, however, are Ohio, Pennsylvania, New York, and Illinois.

22. Boot and Shoe Findings. By boot and shoe findings are chiefly meant lasts, last blocks, shoe forms, shoe trees, shoe pegs, and wooden

Untreated Piling Destroyed by Teredo in Fifteen Months in San Francisco Bay, California

Forest Service experiment. A thorough impregnation with creosote would have protected the piling indefinitely.

Cross-Section of Creosoted Stick of Seasoned Red Oak Treated by open-tank method. Darkened portions show penetration of creosote

Courtesy of C. J. Humphrey

Wood-Destroying Fungi Growing on an Oak Railroad Tie

Simple Method of Treating Butts of Fence-Posts with Creosote

Plate 25—Lumber and Its Uses

TABLE 35

Machine Construction

(Annual lumber consumption, 69 million board feet)

Woods Used	Per Cent
Yellow Pine	33
Cypress	23
Oak	12
White Pine	8
Maple	5
Hemlock	5
Yellow Poplar	3
Ash	2
Basswood	2
Hickory	2
Douglas Fir	1
Elm	1
Spruce	1
Beech	1
Other Woods	1
Total	100

heels. The material for these articles goes to the factory in log or bolt form; and the amount annually required is equivalent to about 66 million board feet of lumber. That the manufacture of these small articles is after all no mean industry, is proved by the fact that the amount of wood used for boot and shoe findings in the State of Maine is greater than that used by the shipyards and boat and canoe builders of that State.

Shoe lasts are made very largely from maple; while basswood is used for forms or fillers. A small amount of birch is also used for lasts, and shoe pegs and shanks are made of it. Wooden heels are made of maple.

The manufacture of lasts is one of the most painstaking operations in the wood-using industries. The last blocks are air dried for a long time, and then very slowly dried by artificial heat for as much as two years before they are turned to the finished pattern. Maple is preferred for lasts, because it is hard, smooth, and tough, takes a high polish, does not warp or shrink, and stands up well under the severe wear to which lasts are subjected.

Among the more important States in the manufacture of boot and shoe findings, are New York, Michigan, Massachusetts, and Maine.

TABLE 36

Boot and Shoe Findings

(Annual wood consumption, 66 million board feet)

Woods Used	Per Cent
Maple	82
Birch	11
Basswood	5
Beech	1
Other Woods	1
Total	100

23. Picture Frames and Moldings. Although small articles in themselves, the manufacture of picture frames and moldings in the United States annually consumes about 65 million feet of lumber of more than thirty species. Of this total, basswood, oak, and red gum supply two-thirds; and of the remainder, white and yellow pine, birch, yellow poplar, chestnut, and beech are the more important woods.

Oak is largely used for picture frames because of its ornamental value; white pine, basswood, and yellow poplar, because they are light, easily worked, and take finishes and enamel well; while such woods as birch, red gum, mahogany, walnut, rosewood, etc., are used for hand mirrors, where both facing and backing must present an ornamental appearance.

Illinois uses by far the largest quantity of wood of any State in the manufacture of picture frames and moldings; while other important States in the production of these articles are New York, Michigan, Indiana, and Ohio.

TABLE 37

Picture Frames and Moldings

(Annual lumber consumption, 65 million board feet)

Woods Used	Per Cent
Basswood	31
Oak	25
Red Gum	12
White Pine	9
Yellow Pine	8
Birch	5
Yellow Poplar	3
Chestnut	2
Beech	2
Other Woods	3
Total	100

24. Shuttles, Spools, and Bobbins. The manufacture of shuttles, spools, and bobbins requires practically as much wood as do picture frames and moldings. It constitutes an important industry in many States, and especially in Maine.

TABLE 38

Shuttles, Spools, and Bobbins

(Annual wood consumption, 65 million board feet)

Woods Used	Per Cent
Birch	51
Maple	21
Dogwood	11
Beech	5
Persimmon	4
Basswood	3
Hickory	1
Yellow Poplar	1
Other Woods	3
Total	100

Spools are made chiefly from paper birch; and, in addition to the quantity used at home, several million feet of spool stock are annually exported from Maine to Scotland. Only birch is used in the manufacture of small, one-piece spools. Three-piece spools are also made of yellow poplar and red gum. Bobbins are made from maple, birch, and beech; while shuttles—which, for factory purposes, must be exceedingly resistant to wear, are made almost entirely from dogwood and persimmon. These woods are very dense, hard, and strong, and become extremely smooth with wear.

Maine uses nearly one-third of all the material consumed in the United States for shuttles, spools, and bobbins; New Hampshire, about one-eighth; while Massachusetts, Vermont, and New York produce the articles in lesser quantities. Tennessee is perhaps the most important State in supplying the dogwood and persimmon used

in the Northern factories for the manufacture of shuttles.

25. Tobacco Boxes. The standard material for cigar boxes is Spanish cedar. The highest-grade boxes are made entirely of this wood, while the cheaper boxes often have a veneer of Spanish cedar laid over a backing of tupelo, yellow poplar, red gum, or some cheaper wood. These latter woods are sometimes stained to imitate Spanish cedar without the application of the more costly veneer. In addition to the woods shown in Table 39, smaller quantities of oak, cedar, sycamore, white pine, mahogany, magnolia, redwood, African cedar, maple, cottonwood, circassian walnut, and rosewood are also used.

Containers for plug, smoking, and chewing tobacco are largely made from sycamore and red gum, usually in the form of three-ply veneer.

TABLE 39

Tobacco Boxes

(Annual lumber consumption, 63 million board feet)

Woods Used	Per Cent
Spanish Cedar	47
Tupelo	16
Yellow Poplar	12
Red Gum	11
Basswood	7
Elm	3
Cypress	2
Other Woods	2
Total	100

Among the more prominent States in the

manufacture of cigar and tobacco boxes, are Missouri, Wisconsin, Ohio, Pennsylvania, and Alabama.

26. Sewing Machines. The manufacture of sewing machines annually requires about 60 million feet of lumber, of which oak and red gum each supply nearly one-third, and yellow poplar and black walnut each a little more than one-eighth, the balance being made up of tupelo, chestnut, cottonwood, maple, basswood, birch, sycamore, mahogany, yellow pine, and redwood.

Tops of sewing machines are usually made of hardwood veneer such as oak or walnut, or of other woods stained to imitate mahogany. In addition to its use for veneered tops, red gum is used in sewing machine parts and for veneer backing, as is also tupelo. The sewing machine industry is rather local, and centered most largely in Indiana and Illinois.

TABLE 40

Sewing Machines

(Annual lumber consumption, 60 million board feet)

Woods Used	Per Cent
Oak	32
Red Gum	32
Yellow Poplar	13
Black Walnut	13
Tupelo	7
Chestnut	1
Other Woods	2
Total	100

27. Pumps and Wood Pipe. While many

more pumps and parts of pumps are made of other materials than was once the case, the pump-making industry consumes a considerable quantity of wood in the form of piping, tubing, rods, handles, platforms, buckets, cylinders, etc.

TABLE 41

Pumps and Wood Pipe

(Annual lumber consumption, 56 million board feet)

Woods Used	Per Cent
Douglas Fir	38
White Pine	22
Redwood	16
Red Gum	6
Cypress	4
Yellow Poplar	3
Maple	3
Ash	2
Hickory	2
Oak	1
Tupelo	1
Larch	1
Other Woods	1
Total	100

White pine is largely used for piping, tubing, siding, curbing, and covering. Well buckets are made of maple, ash, beech, and oak; pump handles and rods, of oak, ash, and beech; water pipes, of yellow poplar, maple, and white pine; and platforms, of cypress. Shortleaf pine and cypress are used for boxes for chain and bucket pumps; tupelo, for pump stocks; and short and longleaf pine, for pump poles. In the West, Douglas fir and redwood are largely used for pumps, and more especially for wood pipe,

where some exceptionally large pipes of this character carry city water supplies.

28. Automobiles. Statistics of the consumption of wood in automobile manufacture are by no means complete, since, in many cases, the reports do not distinguish between the manufacture of automobiles and that of other vehicles. Such figures as are available, however, indicate the percentage of various woods used as shown in Table 42.

Automobile manufacturers generally demand high grades of lumber. Ash, oak, longleaf pine, and birch are employed for frames; hickory, for wheels; elm, for the interior of bodies; yellow poplar, black and circassian walnut, birch, and red gum, for the finish of tops and bodies. The wood finisher employs his highest art in giving a fine appearance to automobiles, and he must have good materials with which to work.

TABLE 42

Automobiles

(Annual lumber consumption, 37 million board feet)

Woods Used	Per Cent
Ash	22
Hickory	19
Yellow Poplar	19
Birch	11
Maple	11
Elm	8
Oak	2
Other Woods	8
Total	100

29. Pulleys and Conveyors. The manufacture of pulleys and conveyors requires about 36 million feet of wood annually, of which red gum supplies more than one-half, and oak one-fifth, the balance being made up of some twenty species, of which maple, birch, beech, tupelo, and basswood are the most important.

Pulleys and conveyors are manufactured in many different places; but such statistics as are available indicate that by far the largest proportion of the output comes from Kentucky, with a decidedly smaller amount from Indiana and Michigan.

TABLE 43

Pulleys and Conveyors

(Annual lumber consumption, 36 million board feet)

Woods Used	Per Cent
Red Gum	55
Oak	20
Maple	7
Birch	6
Beech	2
Tupelo	2
Basswood	2
Ash	1
Yellow Poplar	1
Other Woods	4
Total	100

30. Professional and Scientific Instruments. The manufacture of professional and scientific instruments of a wide variety requires more than thirty domestic and foreign woods amounting to an annual total of about 35 million feet. Pencils

TABLE 44

Professional and Scientific Instruments

(Annual wood consumption, 35 million board feet)

Woods Used	Per Cent
Cedar	57
Maple	14
Basswood	7
Beech	4
Birch	3
Yellow Poplar	3
Hickory	3
Cherry	2
Boxwood	2
White Pine	2
Other Woods	3
Total	100

are included, however, in this classification; and for them Southern red cedar is chiefly used, because of its softness, straight, even grain, and good whittling qualities. Maple is largely used in the manufacture of rulers, yard sticks, camera boxes, and other articles. Basswood finds a large use in the making of yard sticks, drafting tables, alphabet blocks, and advertising novelties. Penholders are chiefly made from red gum; level blocks, from cherry; thermometers, from oak; planes, from beech; surveyors' stakes, from oak, longleaf pine, chestnut, and hickory; drafting tables and equipment, from ash, basswood, beech, mahogany, birch, and white pine; and camera boxes and parts, from basswood, beech, butternut, cypress, hickory, mahogany, spruce, maple, oak, and yellow poplar.

The State of New York is by far the largest

producer of professional and scientific instruments. New Jersey comes next; and Michigan, third.

31. Toys. Basswood and maple supply more than two-fifths of the wood used in toy making, basswood being often used for the bottoms of children's wagons and carts, while the seats and rims are made from maple. Axles, spokes, and rims are made from oak; spokes and frames, from ash; and sled tops, from chestnut. Dominoes and checkers are made from both maple and basswood, while toy blocks are made chiefly from basswood and some yellow poplar. Toy wagons and sleds are also made from birch; doll furniture, from white pine, birch, maple, and beech; doll houses, from birch and basswood; while many turned toys are made from birch.

TABLE 45

Toys

(Annual lumber consumption, 29 million board feet)

Woods Used	Per Cent
Basswood	30
Maple	14
Beech	11
Birch	11
White Pine	8
Elm	7
Oak	5
Chestnut	3
Ash	3
Yellow Poplar	3
Red Gum	2
Cottonwood	1
Other Woods	2
Total	100

In the manufacture of toys, Pennsylvania is the leading State, followed very closely by Wisconsin, Maine, and New York.

32. Sporting and Athletic Goods. More than 30 different woods contribute to the total of 25 million feet of timber annually required in the manufacture of sporting and athletic goods. Of this quantity, hickory and maple supply 40 per cent; elm and ash, each 13 per cent; and oak, 10 per cent.

These goods comprise a long list of articles, including baseball bats, bowling balls, dumb-bells, fishing rods, golf clubs, Indian clubs, skis, snowshoes, tenpins, tennis rackets and many others. Among other purposes, hickory, maple, beech, and ash are used for baseball bats; elm, for gymnasium goods; and maple, for tenpins. A great deal of oak is used for billiard and pool tables, and rosewood for the exterior finish. Maple is used for billiard cues, with black walnut, ebony, circassian walnut, and rosewood for the decorative parts. Yellow pine is used in the manufacture of bowling alleys; and also a great deal of maple. Lignum vitae is the preferred wood for bowling balls. Golf clubs are usually made with hickory handles and persimmon heads. Climbing poles may be made of yellow pine; and vaulting poles, of spruce. Altogether, the demands upon the woods used for sporting and athletic goods are many and varied, but the qualities of strength and toughness are the ones most largely required.

In the manufacture of these goods, Michigan holds first place, with New York, Tennessee, and Illinois following in close order.

TABLE 46

Sporting and Athletic Goods

(Annual wood consumption, 25 million board feet)

Woods Used	Per Cent
Hickory	20
Maple	20
Elm	13
Ash	13
Oak	10
Birch	4
Yellow Poplar	4
Yellow Pine	4
White Pine	3
Basswood	1
Other Woods	8
Total	100

33. Patterns and Flasks. The reports group the woods used for patterns and flasks, although they really have no property in common, and very different grades of material are required for the two purposes. For pattern making, soft, even-grained, easily worked woods which swell and shrink very little are required; while, for the foundry flasks which hold the sand and patterns, almost any wood will do.

By far the larger proportion of patterns are made from white pine, although, for specially fine castings—in which it is important to have durable patterns that can be used many times without wear or swelling and shrinking—expensive woods like mahogany and cherry are used.

Because of its resistance to wear, white oak is also employed to some extent for patterns. Flasks are made from yellow pine, white pine, hemlock, redwood, and a number of other woods.

In the manufacture of patterns and flasks, Pennsylvania seems to have a decided lead; while New Jersey and Ohio use more wood for these purposes than any other State except Pennsylvania.

TABLE 47

Patterns and Flasks

(Annual lumber consumption, 24 million board feet)

Woods Used	Per Cent
White Pine	75
Yellow Pine	8
Redwood	4
Hemlock	2
Spruce	2
Yellow Poplar	1
Sugar Pine	1
Mahogany	1
Cedar	1
Other Woods	5
Total	100

34. Bungs and Faucets. The manufacture of such apparently insignificant articles as bungs and faucets annually requires more than 20 million board feet of wood, of which yellow poplar supplies 85 per cent. This wood is preferred because it is straight-grained, soft, and easily worked, and because it contracts and expands evenly. The even expansion of the bung is what causes it to fit tightly and prevent leakage.

By far the larger proportion of the bungs manufactured are produced in the State of Ohio, and especially in Cincinnati, although the yellow poplar from which they are made comes mainly from Kentucky, Tennessee, and West Virginia.

TABLE 48

Bungs and Faucets

(Annual wood consumption, 21 million board feet)

Woods Used	Per Cent
Yellow Poplar	85
Maple	4
Beech	4
Red Gum	2
Birch	1
White Pine	1
Oak	1
Other woods	2
Total	100

35. Plumbers' Woodwork. For plumbers' woodwork, about the same quantity of wood is required as for bungs and faucets. Under this heading is included the wood used in the manufacture of bathtubs, toilet tanks, seats, bathroom cabinets, and other plumbers' equipment. Oak is the chief wood for these purposes, with birch second, and much smaller quantities of a dozen other woods consumed. For exterior work where a fine appearance is desired, oak is most largely used, together with birch, cherry, and mahogany. Maple and yellow poplar are employed for painted or enameled work; and yellow poplar, chestnut, red gum, and shortleaf

pine, for tank backing. Ash is often used for wash-tray frames.

TABLE 49

Plumbers' Woodwork

(Annual lumber consumption, 20 million board feet)

Woods Used	Per Cent
Oak	70
Birch	12
Yellow Poplar	4
White Pine	4
Ash	3
Red Gum	2
Maple	2
Yellow Pine	1
Basswood	1
Other Woods	1
Total	100

36. Electrical Machinery and Apparatus. Oak is the leading wood in the manufacture of electrical machinery and apparatus, while white pine and spruce are also of much importance. The three supply 55 per cent of the annual requirement of about 18 million feet. Many other woods are used in smaller quantity.

Much of the spruce is used in the manufacture of conduits, reels, and spools for wire; while some birch, white pine, yellow poplar, red gum, and basswood are also used for this purpose. Railway signal devices require most of the white cedar and cypress used in this industry, since these woods offer good resistance to the elements. Rough telephone boxes are made of hemlock, oak, yellow poplar, and maple; while

Creosoted Block of Longleaf Pine after Five Years' Service in Congress Street Pavement, Chicago, Ill.

Photo by courtesy of U. S. Wood Preserving Co.

Laying Creosoted Wood Block Pavement in Chicago

Plate 26—Lumber and Its Uses

Interior of a Sawmill, Showing Method of Timber Construction

Maple Flooring in a Dancing Hall

Plate 27—Lumber and Its Uses

telephone booths—in which appearance is important—are made from such woods as oak and birch. Yellow poplar and oak are used for the base blocks for electrical devices; while many high-grade woods are used in switchboards and telephone cabinets.

Illinois seems to be the most prominent State in the manufacture of electrical machinery and apparatus, but large quantities are also produced in New York and Pennsylvania.

TABLE 50

Electrical Machinery and Apparatus

(Annual lumber consumption, 18 million board feet)

Woods Used	Per Cent
Oak	27
White Pine	17
Spruce	11
Yellow Pine	7
Maple	7
Birch	4
Cedar	4
Larch	4
Yellow Poplar	3
Elm	3
Walnut	3
Beech	2
Mahogany	2
Basswood	2
Hemlock	1
Red Gum	1
Cypress	1
Other Woods	1
Total	100

37. Brushes. The manufacture of brushes consumes about 13 million feet of wood annually of more than thirty species, of which beech sup-

plies nearly half, and birch and maple each 15 per cent.

There are so many different kinds, grades, and sizes of brushes and brooms that there is a wide range in the quality of material employed. The more expensive hand brushes have backs artistically turned from ebony, mahogany, rosewood, maple, cherry, walnut, and birch; while, for scrubbing and whitewash brushes, beech is very largely used. Maple, beech, and birch are employed for paint brushes, as well as for duster handles. For many of the cheaper brushes, various woods are used.

Pennsylvania uses more wood than any other State in the manufacture of brushes; while Ohio, New York, Maryland, Maine, and Massachusetts are also prominent in the production of these articles.

TABLE 51

Brushes

(Annual wood consumption, 13 million board feet)

Woods Used	Per Cent
Beech	49
Birch	15
Maple	15
Basswood	6
Cherry	4
Red Gum	2
Yellow Poplar	2
Elm	1
Hickory	1
Other Woods	5
Total	100

38. Dowels. Dowels are wooden pegs used to

hold boards together, edge to edge, in the manufacture of table tops and counters, or to hold the parts of sash, doors, and similar articles together. They are usually made of the strongest hardwoods, and are driven tightly into auger or gimlet holes to make strong, close-fitting joints. More than 90 per cent of the dowels are made from birch, beech, and maple, and especially from paper birch. Dowels are occasionally made from oak, hickory, or ash.

Dowel rods are also used in the manufacture of chairs, children's beds, and cribs, and for coops in which poultry is shipped.

The equivalent of about 12 million board feet of lumber is annually consumed in dowel making, and nearly two-thirds of it in the State of Maine. Michigan and New York also produce dowels in considerable quantities.

TABLE 52

Dowels

(Annual wood consumption, 12 million board feet)

Woods Used	Per Cent
Birch	68
Beech	15
Maple	11
Elm	1
Basswood	1
Other Woods	4
Total	100

39. Elevators. Under this heading is included the wood used in the manufacture of elevators and elevator parts, including gates, dumb waiters, platforms, guides, and frames.

Ash and oak are frequently used for the framework and heavy platforms of freight and passenger elevators. Maple is principally used for elevator floors and guides; while white and yellow pine are also used for guides, frames, and platforms in places where great strength is not required. Dumb-waiter cars are made from maple, ash, birch, and some of the lighter woods. Elevator finish is often made of yellow poplar. In the more highly finished elevators, mahogany, ash, birch, and oak are used for interior trim.

New York appears to be the leading State in the manufacture of elevators, while this industry is about of equal magnitude in Illinois and Pennsylvania.

TABLE 58

Elevators

(Annual lumber consumption, 10 million board feet)

Woods Used	Per Cent
Yellow Pine	36
White Pine	17
Maple	16
Hemlock	10
Oak	10
Douglas Fir	4
Yellow Poplar	3
Ash	1
Other Woods	3
Total	100

40. Saddles and Harness. Strength is an essential element in the woods used in saddle and harness making; so 98 per cent of them are hard-

woods, among which beech and ash are the most prominent.

The principal parts in which wood is used are saddle trees, stirrups, and hames. Ash is largely used for hames, and to some extent, also, are beech, maple, and oak. Stirrups are made of elm or hackberry, with the best ones of oak. In the West, Douglas fir, as well as Oregon maple, is used for saddle trees. Pack saddles are made from Oregon cottonwood, alder, or ash.

TABLE 54

Saddles and Harness

(Annual wood consumption, 9 million board feet)

Woods Used	Per Cent
Beech	30
Ash	23
Maple	16
Oak	14
Red Gum	12
Elm	3
Douglas Fir	1
Other Woods	1
Total	100

41. Playground Equipment. Under this heading are included merry-go-rounds, lawn and other swings, athletic platforms, and various field appliances. Since nearly all such equipment requires strength and wearing qualities, it is not surprising that almost 90 per cent of the 9 million feet of wood annually used for this purpose consists of beech, oak, yellow pine, and maple.

Because of its strength and toughness, beech

is much used for swings where subject to vibration and irregular strains. Longleaf pine is much used for the platform sills of merry-go-rounds; and so are also Douglas fir and oak. Birch and other woods are used for lawn swings and settees; and black ash, for porch swings. Elm is frequently used for bent parts in playground equipment; and maple, for the exterior finish of merry-go-rounds.

Among the more prominent States in the manufacture of such equipment are Indiana, Pennsylvania, Ohio, and New York.

TABLE 55

Playground Equipment

(Annual lumber consumption, 9 million board feet)

Woods Used	Per Cent
Beech	34
Oak	28
Yellow Pine	16
Maple	9
Elm	4
Ash	2
Birch	2
Spruce	1
Hickory	1
Yellow Poplar	1
Other Woods	2
Total	100

42. Insulator Pins and Brackets. Practically the only woods used in the manufacture of insulator pins and brackets are black locust and white or chestnut oak. Because of its exceedingly great strength and durability, black locust has always been the favorite wood for this

purpose; but the demand for pins and brackets has become so great that much oak also is now used, the pins and brackets of this wood being given a treatment with a preservative to prevent decay. On high-power lines with large porcelain insulators, hickory pins are used to some extent.

Nearly all of the insulator pins and brackets are manufactured in North Carolina and Virginia, where suitable raw material is most abundant.

TABLE 56

Insulator Pins and Brackets

(Annual wood consumption, 9 million board feet)

Woods Used	Per Cent
Locust	53
Oak	47
Total	100

43. Butcher Blocks and Skewers. Butcher blocks are chiefly made from maple, red gum, and sycamore; while skewers are made most largely from hickory, beech, and birch. Strength and toughness are essential qualities in skewers, since they must be of small size; while a dense fiber that resists chopping and does not splinter up is required for meat blocks. In the earlier days, these blocks were chiefly made from solid sections of sycamore, but the practice at present is to build them up from ordinary sizes of lumber.

TABLE 57

Butcher Blocks and Skewers

(Annual wood consumption, 8 million board feet)

Woods Used	Per Cent
Maple	26
Red Gum	22
Sycamore	20
Hickory	16
Beech	11
Birch	3
White Pine	2
Total	100

44. Clocks. The clock-making industry in the United States requires annually the equivalent of about 8 million feet of lumber, used chiefly for cases. Large clocks of the "grandfather" type are now much in fashion; and in the making of such cases, some of the finer woods and the highest class of work are employed. Oak is much used for clock frames; birch, for turnery; and walnut, mahogany, and cherry, for decorative effects in the higher-priced articles. Clock bottoms are made of pine; while the shipping cases are frequently made from yellow pine, which accounts for much of this wood shown in Table 58. Red oak is much used in the manufacture of cases for wall clocks; and basswood and yellow poplar, for backs and also for cases which are to be enameled. Red gum is used to a considerable extent for cases in which a circassian walnut effect is desired.

About 60 per cent of the wood used in clock manufacture is consumed in Connecticut, and

nearly all the rest in New York, these two States being the only ones in which clock-making is an extensive industry.

TABLE 58

Clocks

(Annual lumber consumption, 8 million board feet)

Woods Used	Per Cent
Oak	33
Basswood	18
Yellow Poplar	14
Yellow Pine	12
White Pine	6
Tupelo	4
Cherry	4
Chestnut	4
Mahogany	3
Other Woods	2
Total	100

45. Signs and Supplies. Under this heading are included the manufacture of professional display boards, stretcher strips for oil paintings, window display racks, and similar articles. White pine, hemlock, and Western yellow pine are much used for these purposes because of their light weight and color, ease of working, and capacity to take paints and oils, the latter being specially required for many kinds of signs. The hardwoods grouped in this classification are chiefly used for display racks and hangers.

Many of the large bill posting boards are not special factory products, but are simply made by nailing up tongued-and-grooved flooring on supports.

TABLE 59

Signs and Supplies

(Annual lumber consumption, 7 million board feet)

Woods Used	Per Cent
White Pine	47
Hemlock	15
Western Yellow Pine	15
Yellow Pine	6
Red Gum	3
Elm	3
Redwood	2
Maple	1
Yellow Poplar	1
Basswood	1
Cottonwood	1
Buckeye	1
Other Woods	4
Total	100

46. Printing Materials. The equivalent of more than 5 million board feet of lumber is annually used in the manufacture of printing materials, of which cherry supplies nearly two-fifths. This classification includes engraving blocks, electrotype blocks, engraving boards, and printing press attachments. Engraving and electrotype blocks and bases are generally made of cherry, basswood, oak, birch, maple, or beech, and sometimes of mahogany. Engravers' boards are generally made of basswood; and the long wooden fingers on cylinder presses, from chestnut. For large wood type which must stand up under heavy service, the hardest of hard maple is used.

Among the more prominent States in the consumption of wood for printing materials, are

New York, Pennsylvania, Maine, and Wisconsin.

TABLE 60

Printing Materials

(Annual lumber consumption, 5 million board feet)

Woods Used	Per Cent
Cherry	39
Maple	13
Ash	7
Basswood	7
Yellow Pine	6
Beech	5
Oak	5
Chestnut	5
Birch	5
Yellow Poplar	3
Elm	2
Mahogany	1
Other Woods	2
Total	100

47. Weighing Apparatus. Approximately the same amount of wood is used in the manufacture of weighing apparatus or scales of various kinds as is required for printing devices and machines. The qualities required are different, however; and consequently we find that three-fifths of the wood used in the manufacture of weighing apparatus consists of spruce and yellow pine, which offer desirable combinations of light weight and strength. Three other harder and stronger woods used to less extent are maple, birch, and beech; while white pine, oak, Douglas fir, yellow poplar, and a half-dozen others make up the remaining 10 per cent of wood material consumed in this industry.

TABLE 61

Weighing Apparatus

(Annual lumber consumption, 5 million board feet)

Woods Used	Per Cent
Spruce	36
Yellow Pine	24
Birch	14
Maple	9
Beech	7
White Pine	3
Oak	3
Douglas Fir	2
Yellow Poplar	1
Other Woods	1
Total	100

48. Whips, Canes, and Umbrella Sticks. The manufacture of such apparently small articles as whips, canes, and umbrella sticks annually requires the equivalent of 5 million board feet of lumber, although much of the material is never put into lumber form, and the rarer imported kinds are purchased by the piece or pound.

Among the native woods used for this purpose, beech supplies 57 per cent of the total consumption; and maple and birch, 33 per cent more, leaving only 10 per cent for some twenty other species. Beech is largely used for whip stocks and umbrella sticks, as are also maple and birch. Handles are frequently made from ebony, while many imported woods and roots are used for the more expensive cane and umbrella sticks.

TABLE 62

Whips, Canes and Umbrella Sticks

(Annual wood consumption, 5 million board feet)

Woods Used	Per Cent
Beech	57
Maple	22
Birch	11
Ebony	4
Hickory	2
Other Woods	4
Total	100

In the manufacture of these articles, New York and Massachusetts hold equal rank, each supplying about 40 per cent of the total product, while the bulk of the remainder comes from Pennsylvania.

49. Brooms and Carpet-Sweepers. Ordinary broom handles are listed with handles; hence this classification relates chiefly to carpet-sweepers.

TABLE 63

Brooms and Carpet-Sweepers

(Annual lumber consumption, 2 million board feet)

Woods Used	Per Cent
Maple	25
Birch	23
Oak	18
Sycamore	12
Ash	10
Red Gum	5
Beech	4
Mahogany	2
Circassian Walnut	1
Total	100

The manufacture of carpet-sweepers on a large

scale is a strictly modern industry, and is centered in Michigan. The making of carpet-sweepers has come to be quite an art; and these articles are finished in a wide variety of durable and ornamental woods, in order to match many styles of house finish and furniture. In addition to the nine woods listed in Table 63, rosewood, laurel, and black walnut are recorded as being used to some extent in the manufacture of carpet-sweepers.

50. Firearms. Black walnut has been the favorite gun-stock wood for many years, and still supplies four-fifths of the wood used in the manufacture of firearms. More recently, however, red gum has come into prominence for stocks in which a circassian walnut effect is desired, while a small percentage of the more expensive firearms carry stocks of the true imported walnut. A small amount of English walnut is also used for pistol stocks, and birch occasionally for gun stocks, while boxwood is a favorite material for gun rods.

Most of the firearms used in this country are made in Connecticut and New York.

TABLE 64

Firearms

(Annual lumber consumption, 2 million board feet)

Woods Used	Per Cent
Black Walnut	81
Red Gum	17
Circassian Walnut	2
Total	100

51. Minor Uses. There are three smaller but important wood-using industries which in the aggregate do not consume much more than the equivalent of 1 million board feet of wood yearly. These are the manufacture of artificial limbs, tobacco pipes, and aeroplanes.

TABLE 65

Minor Uses of Wood in Manufacturing

(Total annual wood consumption, 1 million board feet)

Artificial Limbs—	Per Cent
Birch	51
Maple	21
Willow	8
Hickory	6
Yucca	6
Lancewood	4
Other Woods	4
Total	100

Tobacco Pipes—	Per Cent
French Brier	66
Apple	25
Kalmia	4
Red Gum	2
Other Woods	3
Total	100

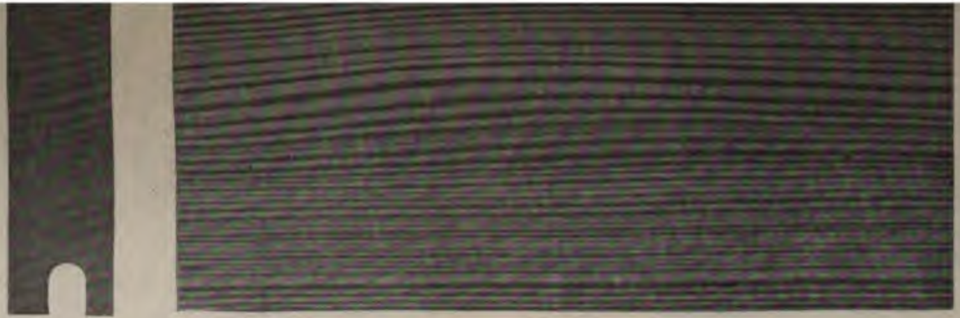
Aeroplanes—	Per Cent
Spruce	63
Ash	16
Mahogany	8
Yellow Poplar	6
Oak	5
Hickory	2
Total	100

The requirements for aeroplane wood are

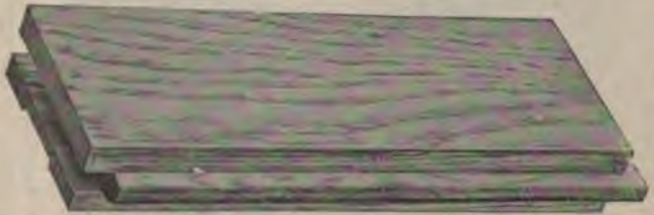
most exacting. Above all, it must be straight-grained, strong, light, and perfectly free from defects. The upright posts which hold the planes apart are chiefly made from spruce; the planes are also made of strips of spruce glued together, or "laminated," which form of construction gives added strength and freedom from splitting under stress. Aeroplane beams are generally of spruce. Ash is often used for the laminated propellers, while hickory is used for the axles and the braces over them. Propellers are also made either wholly of spruce or of built-up layers of ash and mahogany. Mahogany is used in the steering wheels. The skids which hold the landing wheels are usually of oak, ash, or hickory.

WOOD-USING INDUSTRY REPORTS

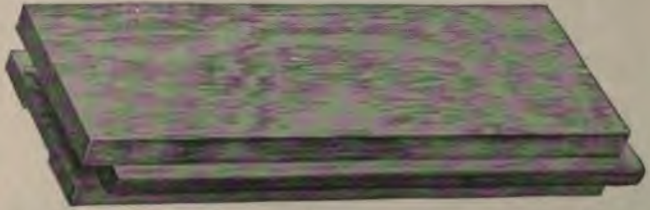
The reports of the United States Forest Service upon the wood-using industries of 24 States are now available, some of the reports being already out of print. Since these reports are mainly of local value, they have been printed by some department of the government of the particular State interested, or by an association or periodical devoted to the interests of lumbering or conservation. The bulletins listed below may be secured in each case from the address given. In writing for those for which there is no charge, postage should accompany the request.



Edge-Grain Yellow Pine Flooring



Plain-Sawed, Tongued-and-Grooved, End-Matched Oak Flooring



Quarter-Sawed, Tongued-and-Grooved, End-Matched Oak Flooring

Plate 28—Lumber and Its Uses

A B C D

Torch Tests Showing Effect of Paint in Preventing Spread of Fire and Retarding Charring of Wood

Effect at end of 1-minute test on untreated shingle (A) and painted shingle (B); 3-minute test, untreated (C), and painted (D).

Forest Service Method of Making Test to Determine End-Crushing Strength, or Strength in Compression Parallel to the Grain

BULLETINS ON WOOD-USING INDUSTRIES OF VARIOUS STATES

State	Obtained from	Price
Alabama	The Lumber Trade Journal, New Orleans, La......	$0.25
California	G. M. Homans, State Forester, Sacramento, Cal....	....
Connecticut	W. O. Filley, State Forester, New Haven, Conn....	....
Florida	W. A. McRae, Com'r of Agric., Tallahassee, Fla....	....
Illinois	J. C. Blair, Univ. of Ill., Urbana, Ill.............	....
Iowa	Iowa State College, Ames, Iowa................	....
Kentucky	J. E. Barton, State Forester, Frankfort, Ky......	....
Louisiana	The Lumber Trade Journal, New Orleans, La.......	.25
Maine	State Forest Commissioner, Augusta, Me..........	....
Michigan	Public Domain Commission, Lansing, Mich.........	....
Minnesota	W. T. Cox, State Forester, St. Paul, Minn.......	....
Mississippi	The Lumber Trade Journal, New Orleans, La......	.25
Missouri	St. Louis Lumberman, St. Louis, Mo.............	.25
New Hampshire	E. A. Hirst, State Forester, Concord, N. H.......	....
New Jersey	Alfred Gaskill, State Forester, Trenton, N. J.......	....
New York	N. Y. State College of Forestry, Syracuse, N. Y.....	....
North Carolina	J. S. Holmes, State Forester, Chapel Hill, N. C....	....
Ohio	Edmund Secrest, State Forester, Wooster, Ohio....	....
Pennsylvania	R. S. Conklin, Com'r of Forestry, Harrisburg, Pa..	....
Tennessee	Southern Lumberman, Nashville, Tenn...........	.25
Texas	The Lumber Trade Journal, New Orleans, La......	.25
Vermont	F. A. Hawes, State Forester, Burlington, Vt.......	....
Virginia	G. W. Koiner, Com'r of Agric., Richmond, Va......	....
Wisconsin	E. M. Griffith, State Forester, Madison, Wis......	....

COMMERCIAL WOODS

THE properties and uses of the principal kinds of timber that are manufactured into lumber in the United States, are briefly mentioned in this chapter; also those of the more important imported woods. The various species are referred to by the names by which they are most widely known; and the order is alphabetic, without regard to the importance of any species in point of lumber production.

Table 107, on page 318, shows the present annual lumber production in the United States. A large percentage of the lumber output goes directly into general building and construction, and there is no way in which the specific uses of such material can be ascertained. The figures given in this chapter upon the consumption of lumber represent chiefly the results of the state and government studies of the wood-using industries, during the course of which a great deal of valuable information has been accumulated upon the factory uses of wood. In order to avoid tiresome figures and to show the true proportions more readily, the tables made up from the statistical reports are in percentages; that is, the percentage of the total factory consumption of each species is shown for each industry in which the species is used, the total factory consumption in each case being 100 per cent.

RED ALDER

Red alder *(Alnus oregona)* is a Pacific Coast hardwood, found chiefly west of the Cascade mountains, in Oregon and Washington. The wood is reddish brown in color, with rather fine, even grain, compact, and hard. It works and polishes well, and makes a good imitation of mahogany when desired.

The main factory uses of red alder are shown in Table 66.

TABLE 66

Factory Uses of Red Alder

Purpose	Per Cent
Furniture	63
Mill Work	19
Handles	16
Other Uses	2
Total	100

The specific uses reported for red alder are for archery bows, broom handles, columns, tables, interior finish, pack saddles, pulleys, and turnery.

APPLE

The domestic apple tree supplies a very compact hardwood that is much prized for a number of small articles. While apple wood is generally cut only when old orchards are cleaned out, the reports indicate a factory consumption of about 300,000 board feet of this wood yearly. The main items of use are as indicated in Table 67.

TABLE 67

Factory Uses of Apple Wood

Purpose	Per Cent
Handles	48
Tobacco Pipes	38
Professional and Scientific Instruments	8
Boxes and Crates	4
Other Uses	2
Total	100

More specifically, applewood is used in the manufacture of planes, mallets, saw handles, rules, canes, whips, and umbrella handles.

ASH

Botanists distinguish a number of species of ash in the United States; but, for commercial purposes, only three are usually specified—white ash, black ash, and Oregon ash.

White ash *(Fraxinus americana)* is slightly under the average weight and hardness of hardwoods, but of more than average strength and stiffness, which makes it very useful for many purposes.

Black ash *(Fraxinus nigra)* is somewhat softer and weaker than white ash. It is much less generally distributed throughout the Eastern States than the former, and is most largely manufactured in Wisconsin and Michigan. The toughness of black ash made it popular wood for split hoops for many years.

Oregon ash *(Fraxinus oregona),* while not very abundant in that State, yields a hard, strong, tough wood which takes an excellent pol-

ish and hence is useful for fixtures and furniture in addition to its main use for handles.

The statistical reports do not separate the various species of ash, and their uses are summarized in Table 68.

TABLE 68

Factory Uses of Ash

Purpose	Per Cent
Handles	22
Woodenware and Novelties	21
Vehicles	15
Furniture and Fixtures	8
Mill Work	7
Refrigerators and Kitchen Cabinets	6
Car Construction	6
Agricultural Implements	4
Boxes and Crates	4
Ship and Boat Building	3
Sporting and Athletic Goods	1
Other Uses	3
Total	100

In addition to the above, particular uses for white ash are for:

Aeroplanes
Automobiles (running boards)
Bars (vehicle)
Baseball bats
Bent panels (light vehicle bodies)
Beams (cultivators)
Baby perambulators
Bobsleds
Bows
Boxes
Butter tubs (heading)
Butter tubs (staves)
Cabinet work
Car construction (framing)
Car repairing
Chairs
Church pews
Churns
Churn lids
Corn planters
Cylinders (cider mill)
Doors
Dowels
Electrical apparatus
Elevator parts
Engine cabs
Felloes
Flooring
Frames (automobile bodies)

Frames (buggy and carriage bodies)
Frames (light vehicle seats)
Frames (wagon boxes)
Furniture
Gears (coach)
Handles
Handles (edge tool)
Hames (wood)
Harrows
Hoe handles
Hose truck bodies
Hounds (vehicles)
Interior finish
Machinery (construction)
Kitchen cabinets
Keels (boat)
Moldings
Panels
Parallel bars
Patterns
Piano parts
Planing mill products
Plow beams
Pokes (animal)
Poles (heavy vehicles)
Posts (vehicles)
Plumbers' woodwork
Pump rods
Rails
Rake heads
Rake (garden) handles
Rims (vehicle)
Refrigerators
Sash
Shovel handles
Soil rollers
Staves
Tables
Tools
Trunks
Vehicle bodies and parts
Yokes
Wagon parts
Well-digging machines
Windmills

Black ash enters into the manufacture of:

Auto seats
Baseball bats
Boat finish
Box shooks
Buffets (exterior work)
Buffets (inside work)
Butter tubs
Candy pails
Chairs (kitchen)
Commodes
Cooperage stock
Desks (inside work)
Fixtures
Flooring
Furniture (interior)
Handles (garden tools)
Handles (small tools)
Hayloader parts
Hoops (butter tubs)
Hoppers (fruit and vegetable)
Ice chests
Interior finish
Kitchen cabinets
Lard tubs
Moldings (piano)
Music cabinets (inside work)
Music cabinets (exterior work)
Picture moldings
Pike poles
Racked hoops
Refrigerators
Sills (vehicle)
Spice kegs
Slats (bed)
Sugar buckets
Trunk slats
Washboards

Oregon ash is used on the Pacific Coast in making boats, book cases, chairs, desks, tables, handles, saddles, and vehicles.

ASPEN

The aspens, of which there two species—the common popple or quaking aspen *(Populus tremuloides)*, and the large-tooth aspen *(Populus grandidentata)*—are widely distributed throughout the United States, and belong to the family of true poplars, of which the cottonwoods are the largest representatives. The wood of the aspens is light in weight and color, soft, and not strong. In stiffness, however, it ranks with many heavier hardwoods.

Aspen is not separately tabulated in many state reports; but probably its largest use is for the making of boxes and crates, to which purpose it is excellently suited. Some of the specific uses listed for aspen are as follows:

Basket bottoms
Basket hoops
Boxes
Boxes (piano)
Boxes (shoe pegs)
Boxes (veneer)
Brushes
Buckets
Casing
Ceiling
Crates
Dowels
Excelsior
Fish kits
Frames (door)
Frames (window)
Furniture (hidden work)
Handles (dipper)
Handles (oyster knife)
Jelly buckets
Novelties
Pails
Shoe fillers
Shoe forms
Shoe lasts
Shoe trees
Spice kegs
Spool heads
Spools
Sugar buckets
Toothpicks
Toys
Toy wheelbarrows (bodies)
Vehicle body parts
Wood wool

BALM OF GILEAD

Balm of Gilead *(Populus balsamifera)* is also a true poplar; and the wood is much like that of its relatives with respect to weight, strength, and uses. The supply is not large, since the tree occurs but infrequently in the Northern States.

Balm of Gilead is used chiefly in the manufacture of boxes and crates, but also has a place in the making of the following articles:

- Berry buckets
- Built-up panels
- Card-table tops
- Ceiling
- Druggist barrels
- Egg-cases
- Excelsior
- Furniture shelving
- Grape baskets
- Handles
- Hat racks
- Novelties
- Pails
- Spindles
- Tubs
- Wood wool

BASSWOOD

With the possible exception of willow and buckeye, basswood *(Tilia americana)* is the lightest, softest, and weakest of the hardwoods. It is neither stiff nor tough, but, because of its even grain, white color, and extreme ease of working, is one of the most widely used woods. The more important factory uses reported are as shown in Table 69.

TABLE 69

Factory Uses of Basswood

Purpose	Per Cent
Boxes and Crates	23
Mill Work	16
Woodwork and Novelties	15
Furniture and Fixtures	11

Trunks and Valises	6
Picture Frames and Molding	5
Excelsior	4
Musical Instruments	3
Toys	2
Agricultural Implements	2
Vehicles	2
Matches	1
Refrigerators and Kitchen Cabinets	1
Car Construction	1
Laundry Appliances	1
Tobacco Boxes	1
Other Uses	6
Total	100

The diversity of the uses of basswood is indicated by the following list of articles in the manufacture of which this wood is used to a greater or less degree:

Agricultural implements
Altars
Apparatus parts (electric)
Automobiles
Backings (furniture)
Backs (organ)
Baseboards
Baskets (fruit and vegetable)
Beehives
Bellows (organ)
Boats
Bookcases (inside work)
Boxes
Breadboards
Bureaus (inside work)
Butter ladles
Cabinets (kitchen)
Cameras
Candy pails
Car construction
Car repairing
Casings (building)
China closets (interior work)
Church pews
Circus seats
Cigar boxes
Cleats (organ)
Clothes bars
Commodes
Coops (poultry)
Cornice
Corn shellers
Couches (box)
Crating
Cupboards
Desks (school)
Drawer bottoms
Engraving boards
Fans (electric)
Feed mills
File cases
Fixtures (bar)
Fixtures (barber shop)
Fixtures (store and office)
Flag poles
Frames (couches)

Frames (davenports)
Frames (hand mirror)
Frames (lounges)
Furniture (church)
Furniture (interior)
Gameboards
Games of chance
Go-carts
Grain separators
Guitars
Handles
Hayloader parts
Heading (barrels)
Hoppers (fruit and vegetable)
Incubators (bodies)
Ironing boards
Interior finish (building)
Kitchen cabinets
Ladders (extension)
Laundry machinery
Lodge furniture
Machinery construction
Mandolins
Millwork
Moldings (casket)
Music cabinets (interior)
Organ cases (folding organ)
Organ frames
Pails
Parlor furniture (frames)
Pastry boards
Patterns
Piano keys
Picture molding
Pipe organs (interior parts)
Pyrography boards
Refrigerators
Sample cases
Seeder boxes (farm implements)
Sheathing (building)
Shoe forms
Siding (house)
Signboards
Staves
Stirrups (head blocks)
Stirrups (neck blocks)
Swing seats
Tables
Thermometers
Threshing machines
Toys
Trunks
Vehicle bodies
Violin cases
Washboards
Washing machines
Yardsticks

BEECH

Beech *(Fagus atropunicea)* is a moderately hard, strong, heavy hardwood that has a wide range of usefulness for many purposes. While the reports indicate a larger consumption of beech in the manufacture of boxes and crates than in any other industry, a large amount is used in general mill work, including flooring and finishing, and for furniture and fixtures, for which purposes the hardness and wear-

resisting qualities of beech are especially desirable.

TABLE 70

Factory Uses of Beech

Purpose	Per Cent
Boxes and Crates	28
Mill Work	21
Furniture and Fixtures	18
Handles	6
Woodenware and Novelties	5
Laundry Appliances	3
Brushes	2
Vehicles	2
Agricultural Implements	2
Musical Instruments	1
Spools and Bobbins	1
Toys	1
Playground Equipment	1
Whips, Canes, etc.	1
Saddles and Hames	1
Other Uses	7
Total	100

A still better idea of the varied uses of beech is obtained from the following partial list of articles into the manufacture of which this wood enters:

Agricultural implements
Auto-seat frames
Balls
Barber chairs
Baseball bats
Baskets
Beds (folding)
Boats
Bobbins
Boxes
Brick molds
Broom handles
Brushes
Built-up panels
Bungs
Butcher blocks
Butter dishes
Butter tubs
Cable reels
Candy pails
Cars
Chair bottoms
Chair rods
Cheese boxes

Churns
Cider mills
Clocks
Clothes pins
Coat hangers
Coops
Crating
Dowels
Drafting tables
Electrotype plates
Faucets
Filing cabinets
Fixtures
Furniture
Hames
Handles
Hand sleds
Interior finish
Ironing boards
Ladders
Lawn swings
Measures
Musical instruments
Mouse traps
Neck yokes
Novelties
Pails
Panels
Piano cases
Pipe organs
Plane stocks
Printers' cabinets
Pulleys
Pumphandles
Pump buckets
Refrigerators
Rims (bicycle)
Rope reels
Sash
Sectional bookcases
Show cases
Skates
Sounding boards
Spindles
Spools
Stanchions
Staves
Stepladders
Tables
Tie plugs
Toys
Trunks
Tubs
Vehicles
Wardrobes
Washing machines
Washboards
Weighing machines
Wheelbarrows
Window screens
Woodenware

BIRCH

Several birches are recognized by botanists and foresters; but from the standpoint of the practical wood user, there are only three important kinds—the paper or white birch *(Betula papyrifera)*, the yellow birch *(Betula lutea)*, and the red or cherry birch *(Betula lenta)*. Paper birch is found across the northern part of the United States and Canada, but is most abun-

dant and commercially important in New England, and especially in Maine. The red or cherry birch occurs in smaller quantity from New York southward through West Virginia; while the yellow birch is common in New York, New England, and the Lake States, but most abundant in the latter region. The heartwood of yellow birch is reddish, and much of it is marketed and used for the same purposes as cherry birch, and, without distinction from the latter, for the manufacture of furniture, interior finish, and the like. The principal uses of the paper or white birch are for spool stock, box lumber, woodenware, dowels, shoe pegs, and other small articles. Closely related to the paper birch is the Western birch *(Betula occidentalis)*, a small amount of which is used for interior finish in Oregon and Washington.

The wood of red and yellow birch is heavy; of average hardness, stiffness, and strength for hardwood; and above the average in toughness. For this reason, birch makes a good wagon hub; and much yellow birch is used for this purpose.

The factory uses of the various birches are summarized in Table 71.

TABLE 71

Factory Uses of Birch

Purpose	Per Cent
Mill Work	28
Furniture and Fixtures	21
Boxes and Crates	19
Spools and Bobbins	7
Woodenware and Novelties	6
Vehicles	3

Musical Instruments	3
Handles	2
Dowels	2
Boot and Shoe Findings	2
Car Construction	1
Agricultural Implements	1
Other Uses	5
Total	100

A tabulation of the uses reported for red and yellow birch gives the following list:

Automobiles
Backgrounds (display windows)
Balusters
Barber chairs
Barber shop furnishings
Barrel starchers (laundry)
Baseboards
Baskets (fruit and vegetable)
Billiard tables
Boat parts
Bobbins
Bodies (light vehicles)
Bookcases (exterior)
Bookcases (interior)
Bookracks
Bottoms (heavy vehicle bodies)
Bottoms (wagons)
Boxes
Boxes (cheese)
Boxes (veneer)
Box shooks
Brackets
Broom handles
Brush blocks
Buffets (bar fixtures)
Bureaus (exterior)
Butter churns (frames)
Butter molds
Cabinets (music rolls)
Cabinets (phonograph records)
Cabinets (toilets)
Cabinet work
Cameras
Canes
Capitals
Carpet sweepers
Carvings
Cases (medicine)
Cases (railroad tickets)
Casing
Caskets
Chair frames (upholstered furniture)
Chairs
Chairs (adjustable)
Chairs (dining room)
Chair seats
Chairs (office)
China closets
Clocks
Coffins
Columns (porch)
Consoles
Cooperage stock (slack)
Cores (veneer)
Counters (bar)
Counters (store and office fixtures)
Cradles

Crating
Creamery accessories
Crutches
Cutting boards (meat)
Doors
Dowels
Dressers
Dressing tables
Electrotype bases
Elevator cars
Equipment (playground)
Farm implement parts
Farm machinery parts
Fixtures (bank)
Fixtures (laboratory)
Fixtures (soda fountain)
Fixtures (store and office)
Flooring
Folding beds
Frames (cheval mirror)
Frames (couches)
Frames (davenports)
Frames (light vehicle bodies)
Frames (light vehicle seats)
Frames (lounges)
Gameboards
Gear parts (light vehicles)
Glove boxes
Grain doors
Grilles
Grille work
Guitars
Hallracks
Handrails (porch)
Handrails (stairworks)
Harp sides (musical instrument)
Hoppers (fruit and vegetable)
Hubs
Interior finish
Key racks
Launch parts
Laundry machines (steam)
Lawn swings
Leaves (table)
Lining (motor boats)
Mandolins
Mantels
Match safes
Match strikers
Mirror backs
Moldings (house)
Moldings (piano)
Newels (stairwork)
Organ cases
Organ cases (exterior pipe organ)
Organ keys
Ornaments (furniture)
Panels (veneered)
Paper plugs
Parlor cabinets (exterior)
Parlor furniture (frames)
Parlor rockers
Parquetry flooring
Passenger cars (interior finish)
Patterns (machine parts)
Pedestals
Pen racks
Pen trays
Piano benches
Piano cases
Piano chairs
Piano keys
Piano players (exterior)
Piano stools
Picture mouldings
Plane handles
Plumbers' woodwork
Pool tables
Pulleys
Posts (stairwork)
Reels (fence wire)
Reels (insulated wire)
Refrigerators
Risers (stairwork)
Road machinery parts

Rocker frames (upholstered furniture)
Sash (window)
Screen doors
Seats (water closets)
Sewing machine parts
Sewing tables
Shells (drum)
Shoe pegs
Shoe trees
Show cases
Sideboards (exterior)
Sills (road carts)
Skewers
Skis
Sleds
Slides (tables)
Sofa frames (parlor furniture)
Somnols
Spools
Stairwork
Steering wheels
Step ladders
Steps (stairwork)
Switchboards (telephone)
Tables
Tables (dressing)
Tables (library)
Tabourets
Tanks (water closets)
Telephones
Telephones (accessories)
Toboggans
Tool chests
Toys
Trunks
Umbrella handles
Veneer cores (piano cases)
Wainscoting
Wall cases (store)
Wardrobes (exterior)
Window screens
Wind shields (automobile)
Woodenware
Work benches
Zither bodies

Among the uses reported for paper or white birch are:

Bails (bucket and pail)
Bobbins
Boxes
Brushes
Camp stools (parts)
Chairs (porch)
Chairs (turned parts)
Checkers
Clothespins
Crates
Crutches
Dowels
Drawer sides
Dry measures
Duster brush blocks
Flooring
Furniture
Handles (awl)
Handles (cant hook)
Handles (corkscrew)
Handles (feather curlers)
Handles (hair curlers)
Handles (hay rake)
Handles (long handle brushes)
Handles (paint brushes)
Handles (shovel)
Handles (toy garden tools)
Hosiery boards
Hoops
Interior finish
Knobs
Liquor logs
Molding (window)

Interior View of a Table Factory in Virginia

Interior of a Box Factory

Finished sides, tops, and bottoms are bundled ready to be shipped to the user who will assemble them

Plate 30—Lumber and Its Uses

Drying Room in a Vehicle Factory
Showing oak and hickory spokes and elm hubs

Drying Room in a Vehicle Factory
Showing oak and hickory rims for buggy wheels; also birch and elm hubs

Plate 31—Lumber and Its Uses

Novelties	Spool barrels
Paint brushes	Spool heads
Paper plugs	Table slides
Piano stools	Toothpicks
Quills	Toy parts (iron toys)
Rungs (turned chair)	Toy wheelbarrows
Sawhorses	Twisters
Shoe pegs	Vehicle parts
Skewers	Wash benches
Speeders	Wash boards
Spindles (turned chair)	Wheels (toy wagons)
Spinning wheels	Wheels (toy wheelbarrows)
Spools	

BUCKEYE

Buckeye *(Aesculus octandra)* is a species of the horse-chestnut family from which about 20 million feet of lumber are annually manufactured in Ohio, Kentucky, and adjacent States. The wood is very much like basswood as regards lightness in weight, softness, and lack of toughness or strength. That these qualities make buckeye useful for very many of the purposes for which basswood is desired, will be seen from the summary of its factory uses given in Table 72.

TABLE 72

Factory Uses of Buckeye

Purpose	Per Cent
Boxes and Crates	47
Excelsior	19
Mill Work	10
Furniture	6
Trunks and Valises	6
Frames and Molding	3
Caskets and Coffins	3
Laundry Appliances	2
Woodenware and Novelties	1

Signs and Supplies	1
Other Uses	2
Total	100

Some of the specific uses reported for buckeye include doors, piano panels, interior finish, sample cases, candy and chocolate boxes, and wooden bowls and dishes.

BUTTERNUT

Butternut *(Juglans cinerea)* is in much the same class as basswood and buckeye in respect to mechanical qualities, but is slightly heavier, harder, stronger, and tougher than these woods. It also has a figure considerably like black walnut, of which it is a close relative, but lacks the rich color of the more valuable wood.

Butternut finds its largest usefulness in the manufacture of furniture and fixtures, and, next, for boxes and crates, as is indicated in Table 73.

TABLE 73

Factory Uses of Butternut

Purpose	Per Cent
Furniture and Fixtures	39
Boxes and Crates	22
Excelsior	11
Mill Work	9
Woodenware and Novelties	6
Musical Instruments	4
Ship and Boat Building	3
Patterns and Flasks	2
Professional and Scientific Instruments	1
Other Uses	3
Total	100

Specific articles in which butternut is used are:

Altars
Boat decks
Boat finish
Boat seats
Cabinets
Cameras
Caskets
Cheese box heading
Church pews
Doll carriages
Furniture
Interior finish
Moulding
Patterns
Piano cases
Piano molding
Screen frames
Show cases
Store fixtures
Tables
Threshing machines
Toys
Vehicles

CEDAR

There are so many woods popularly known by the name "cedar," that this name conveys little idea of the qualities of the timber referred to. Some of these woods are correctly known as cedar, while entirely different names are applied by botanists to the others. In this discussion, it is sufficient to mention seven species which go by the name of cedar, and which have a considerable commercial usefulness — the Southern white cedar *(Chamaecyparis thyoides)* of the Atlantic Coast States; the Northern white cedar or arbor vitae *(Thuja americana)*, chiefly important in New England and the Lake States; the red or pencil cedar *(Juniperus virginiana)*, which is most abundant in Tennessee and Florida; the Western red cedar or giant arbor vitae *(Thuja plicata)* of the Northern Rocky Mountains and Pacific Northwest; the Port Orford cedar *(Chamaecyparis lawsoniana)* of Oregon; the Alaska or yellow cedar *(Chamae-*

cyparis nootkatensis) of the North Pacific Coast from Oregon to Alaska; and the incense cedar *(Librocedrus decurrens)* of Southern Oregon and California. All of these so-called cedars have in common a certain lightness in weight, softness, evenness of grain, and resistance to decay, but in varying degrees.

Both the Northern and Southern white cedars are among the lightest of woods in weight, and are soft and easily worked. They are much used for woodenware and in canoe and boat building, and also for shingles, posts, and poles, by far the larger part of the Northern white cedar being used for the latter purpose. The true red or pencil cedar has always been the standard wood for lead pencils, because it is very soft, with a fine, even grain that whittles nicely. It is also among the most durable of woods when exposed to decay-producing influences.

The Western red cedar is much like the Northern white cedar or arbor vitae, but is a larger tree and produces more red heartwood. At the present time, Western red cedar, in addition to supplying a considerable quantity of lumber, posts, and poles, furnishes about two-thirds of all the shingles made in the United States.

The wood of the incense cedar is considerably heavier and stronger than that of the white or red cedar. In fact, in this respect it compares favorably with Southern yellow pine. Incense cedar wood is close-grained, and has a reddish,

durable, heartwood useful for many purposes.

Port Orford cedar is a wood which is heavy, strong, and stiff. It has a good figure, and polishes well.

The Alaska or yellow cedar has perhaps the hardest wood of any of the so-called cedars. It is light, stiff, and strong, has a good figure, and takes a good polish.

Without distinction as to species, the factory uses of cedar in the United States are summarized in Table 74.

TABLE 74

Factory Uses of Cedar

Purpose	Per Cent
Mill Work	44
Professional and Scientific Instruments	20
Ship and Boat Building	7
Woodenware and Novelties	6
Caskets and Coffins	6
Laundry Appliances	5
Tanks and Silos	4
Furniture and Fixtures	3
Boxes and Crates	2
Other Uses	3
Total	100

In Table 74 the millwork—that is, the manufacture of sash, door, blinds, interior finish, etc. —takes chiefly the Western cedars; while under the heading of professional and scientific instruments is included much of the Eastern red cedar used in pencil making. Smaller uses of Eastern red cedar are for:

Canes
Caskets
Chairs
Chests

Fixtures
Furniture
Interior finish
Musical instruments
Sash
Siding
Silos
Tanks
Umbrella handles
Vehicles
Woodenware

Uses reported for the Eastern white cedars are in the manufacture of:

Boat bottoms
Boat decking
Canoes
Cigar boxes
Dairymen's supplies
General millwork
Ice cream freezers
Interior finish
Oars
Pails
Planing mill products
Roof tanks
Rowboats
Shiplap
Siding
Signal devices
Silos
Tanks
Yachts

A recent compilation by the Forest Service lists the following uses for Western red cedar:

Barrel bungs
Battens
Blinds
Boards
Boats
- Cabins
- Canoes
- Ceiling
- Decking
- Finish
- Launches
- Planking
- Rails
- Roofs
- Skiffs
- Trim

Car construction
- Finish
- Roofing
- Siding
- Trim

Carving
Caskets
- Coffins
- Coffin boxes

Ceiling
Chests
Cigar boxes
Closet linings
Columns
Conservatories
- Sash
- Stands
- Trays

Cooperage
- Buckets
- Tubs

Cores
- Veneer

Decking
Doors
Drain boards

[redacted]

- Drawing boards
- Faucets
- Finish
- Fixtures
  - Drawers
  - Mirror backs
  - Panels
  - Shelves
  - Show cases
- Flooring
- Flume stock
- Framing
- Furniture
  - Bottoms
  - Cabinets
  - Drawer bottoms
  - Frames
  - Panels
- Hot house trays
- Incubators
- Interior work
  - Ceiling
  - Finish
  - Trim
- Lath
- Lattice
- Lintels
- Moldings
- Organs (action)
- Panels
- Patterns
  - Foundry
  - Machine shop
- Piano shanks
- Pickets
- Picture frames
- Piling
- Poles
- Pontoon floats
- Porch columns
  - Built-up
  - Turned
- Posts
- Sash
  - Hot house
  - Window
- Scroll work
- Shingles
- Shiplap
- Shop lumber
- Siding
  - Bevel
  - Drop
- Silos
- Spigots
- Spindles
- Tanks
  - Covers
  - Staves
- Tennis rackets
  - Handles
- Tent poles
- Ties
- Totem poles
- Trays
  - Fruit dryer
  - Hot house
  - Trunk
- Turning
  - Balusters
  - Novelties
  - Squares
- Veneers (cores)
- Washing machines
- Window frames
- Window sills

According to the Oregon reports, Port Orford cedar is used for boats (finish, frames, planking, skiffs), columns, fixtures, furniture (cabinets, moth-proof drawers, stools, tables), moth-

proof chests, matches, sash and doors, and turnery.

Alaska or yellow cedar is used for boat cabins, interior finish, carvings, patterns, and pyrography. In addition to serving many other purposes, incense cedar is now being used for pencil making, because of the shortness of the supply of Southern red cedar.

CHERRY

The wild black cherry *(Prunus serotina)* is somewhat lighter in weight and a little softer than beech and birch; but it is nevertheless a dense, strong, hardwood of excellent wearing qualities, and with a color and figure which make it highly prized in the manufacture of exceptionally fine furniture and interior finish. The supply is not large, and Table 75 indicates that

TABLE 75

Factory Uses of Cherry

Purpose	Per Cent
Furniture and Fixtures	24
Printing Material	17
Car Construction	16
Mill Work	14
Professional and Scientific Instruments	6
Handles	5
Brushes	4
Musical Instruments	3
Clocks	3
Ship and Boat Building	2
Boxes and Crates	1
Patterns	1
Other Uses	4
Total	100

nearly all the cherry is used for high-grade work.

Specific uses reported for cherry are for:

Baskets
Beds
Boat finish
Bookcases
Brick molds
Brushes
Bushel crates
Butter dishes
Cabinets
Camera boxes
Card trays
Cars (finish)
Casing
Caskets
Chairs (posts, rounds)
Clock cases
Coffins
Collar trays
Counters
Desks
Doors
Dowels
Dressers
Flasks
Flooring
Electrotype blocks
Engraving blocks
Glove stretchers
Handles (duster brush)
Handles (saw)
Interior finish
Last blocks
Level blocks
Level sticks
Library furniture
Machine boxes
Musical instruments
Office fixtures
Panels
Partitions
Parquetry
Passenger cars
Patterns
Piano actions
Piano cases
Piano players
Piano rails
Picture moldings
Pilot wheels
Pipe organ (cases, actions)
Plumbers' woodwork
Plane handles
Road machines (cabs, boxes)
Sash
School furniture
Settees
Shoe lasts
Siding
Spindle stock
Spoons
Store fixtures
Swings
Switchboards
Tables
Table drawers
Table legs
Tobacco pipes
Trays (jewelry)
Trim
Woodenware

CHESTNUT

The wood of chestnut *(Castanea dentata)* is rather light, soft, and durable. It is easily

worked, and appears well in furniture and fixtures, in many cases rather closely resembling white ash. The larger factory uses reported for chestnut are indicated in Table 76.

TABLE 76

Factory Uses of Chestnut

Purpose	Per Cent
Mill Work	28
Furniture and Fixtures	19
Caskets and Coffins	16
Musical Instruments	13
Boxes and Crates	12
Woodenware and Novelties	7
Other Uses	5
Total	100

Articles in which chestnut is used are:

Boxes (cheese)
Boxes (glass bottles)
Boxes (handle)
Boxes (meat)
Brushes
Cabbage crates
Casing
Casket moulding
Casket shells
Casket tops
Church pews
Cores (veneer)
Crating
Doors
Fence pickets
Fence stubs
Flooring
Furniture (backs)
Furniture frames (case goods)
Furniture (kitchen)
Ice chests
Interior finish (house)
Library tables
Mantels
Molding
Outer cases (caskets)
Panel work (house)
Picture frames
Pool table sides
Refrigerators
Ribs (poultry coops)
Sash
Siding
Stair balusters
Stair rails
Stair rises
Store and office partitions
Veneer backing
Wardrobes

COTTONWOOD

The cottonwoods or true poplars yield light, soft, even-grained, easily worked woods, more closely resembling basswood than any other species. Cottonwood, however, is tougher and stiffer than basswood, and, because of its interwoven fibers, resists wear extremely well for such a soft wood. The bulk of the cottonwood lumber is manufactured from the common Eastern cottonwood *(Populus deltoides)*, which is most abundant in the lower Mississippi valley. In Oregon and Washington, the black cottonwood *(Populus trichocarpa)* yields a lumber which is used for the same purposes as that of the Eastern species.

Because of its lightness and strength, cottonwood is a favorite material with box makers, as will be seen from Table 77.

TABLE 77

Factory Uses of Cottonwood

Purpose	Per Cent
Boxes and Crates	56
Excelsior	14
Vehicles	9
Mill Work	6
Agricultural Implements	4
Woodenware and Novelties	4
Furniture and Fixtures	2
Refrigerators and Kitchen Cabinets	1
Other Uses	4
Total	100

Particular uses reported for Eastern cottonwood are for:

[redacted]

Agricultural implements
Backs (washboards)
Baskets
Berry boxes
Bevel siding
Bookcases (inside work)
Boxboards (heavy vehicles)
Boxes
Boxes (manure spreaders)
Box shooks
Brooders (poultry)
Buggy backs
Car construction (rafters)
Car repairing parts
Carts
China closets
Clothboards
Coffins
Commodes
Corn binder parts
Corn shellers
Cornice
Cultivator parts
Cupboards (kitchen)
Crating
Dowels (chair)
Drawers
Drill boxes (farm implements)
Drills (farm implements)
Drop siding
Egg cases
Ensilage cutters
Envelope cutters
Eveners (harrow)
Fixtures (bar)
Fixtures (store and office)
Fodder shredders
Frames (canopy)
Furniture (inside work)
Incubators
Interior trimmings
Ironing-boards
Kitchen cabinets
Ladders
Manure spreaders (beds)
Millwork
Mortar boards
Music cabinets (inside work)
Packages (fruit and vegetable)
Panels (light vehicle bodies)
Panels (spring wagon bodies)
Piano cases (veneer cases)
Refrigerators
Saddle trees
Sample cases
Seeders, boxes (farm implements)
Self-feeders (threshing machines)
Separator sides (threshers)
Shelving
Shipping cases (butter)
Siding (washboards)
Stacker parts (farm machinery)
Tables
Trunks
Vehicle bodies
Vehicle seat backs
Vending machines
Wagon beds
Wheelbarrows
Woodenware

The Oregon or black cottonwood is used in Oregon and Washington for:

Baskets, boxes, candy barrels, caskets, cores of veneered products, excelsior, farm machinery, furniture (chair seats, couch heads, drawer bottoms, shelving), fixtures (drawer bot-

toms, shelving), pack saddles, pulleys, trunks, veneer, woodenware.

CUCUMBER

The tree commonly known as cucumber is one of the magnolias *(Magnolia acuminata).* The wood is soft, light, easily worked, durable, and very similar to yellow poplar, with which lumber much of it is marketed.

So far as separate uses are reported for cucumber, they are as indicated in Table 78.

TABLE 78

Factory Uses of Cucumber

Purpose	Per Cent
Mill Work	50
Woodenware and Novelties	23
Boxes and Crates	18
Excelsior	6
Other Uses	3
Total	100

Cucumber enters into the manufacture of:

Agricultural implements
Cabinets
Casing
Casket trim
Ceiling
Cheese boxes (heads)
Doors
Flooring
Frames
Furniture
Hay racks
Molding
Pails
Partition
Porch columns
Siding
Stairs
Trim
Tubs

CYPRESS

Cypress *(Taxodium distichum)* is one of the stronger and heavier softwoods, which, with the

exception of greater weight, perhaps resembles redwood more closely than it does any other conifer. Cypress is one of the more durable woods; and some remarkable records of the longevity of cypress lumber and shingles are claimed by the manufacturers of this wood. Cypress works well, has a good figure, and a rich color in the red variety. The largest usefulness of cypress is in mill work, so far as factory purposes are concerned, as will be seen from Table 79.

TABLE 79

Factory Uses of Cypress

Purpose	Per Cent
Mill Work	76
Boxes and Crates	6
Tanks and Silos	5
Caskets and Coffins	3
Machine Construction	2
Laundry Appliances	2
Woodenware and Novelties	1
Furniture and Fixtures	1
Other Uses	4
Total	100

Because of its durability, cypress is also much used for siding, shingles, railroad ties, and other purposes where it is exposed to decay-producing influences—among these latter uses being greenhouse construction.

The wide range of usefulness of cypress is indicated by the following list of articles into the manufacture of which this wood enters:

Agricultural Implements
Altars
Balusters (porch)
Baseboards

Beehives
Blinds
Boat parts
Boat siding
Bottoms (oil tanks)
Bottoms (water tanks)
Boxes
Butter tubs
Cabinets (ice cream)
Cabinet work
Candy pails
Carvings
Casing (house)
Casing (incubators)
Caskets
Churns
Cisterns
Cold frames (hotbeds)
Colonnades
Columns (porches)
Conservatories
Conveyors
Cornice
Covers (laundry machines)
Crating
Decking
Discs (laundry machines)
Door frames
Doors
Drawers (bottoms)
Drawers (ends)
Drawer sides (furniture)
Dropboards (poultry)
Dust arrester parts
Electric cars (interior work)
Feed mills
Finish (boats)
Fixtures (bank)
Fixtures (soda fountains)
Fixtures (store and office)
Flasks
Flour mills (machine parts)
Frames (vapor bath tubs)
Frames (window tents)
Grain elevators
Greenhouses
Hay baler parts
Hay loader parts
Hoppers (poultry houses)
Ice cream freezers
Incubator parts
Interior finish
Knifeboards (mowers)
Launch parts
Lodge furniture
Mantels
Musical instruments
Nests (poultry houses)
Pails
Panels (delivery wagons)
Panels (doors)
Panels (light vehicle bodies)
Patterns
Picture moldings
Porch work
Pumps
Refrigerators
Road rollers
Roof slats (light vehicle beds)
Sash (storm)
Screen doors
Siding
Signal devices
Silos
Spindles
Spraying apparatus
Stairwork
Starchers (laundry)
Staves (oil tanks)
Staves (water tanks)
Stepping
Store fronts
Tanks
Tanks (water closets)
Towers (tanks)
Trunks
Tubs (laundry)
Vats

Vats (vinegar)
Washers (hydraulic)
Washing machines (hand)
Water closets (unexposed parts)
Water pipes
Well machinery
Well tubing
Window frames
Window screens
Windmills
Wringers (laundry)

DOGWOOD

Dogwood *(Cornus florida)* is very hard, heavy, close-grained, and wear-resistant, and is used in places where hard service would quickly destroy softer woods. As brought out elsewhere, the limited supply of dogwood is nearly all consumed in the manufacture of shuttles for the great cotton mills of the East.

Dogwood is also used to some extent for small handles, mauls, spindles, wedges, and mine rollers.

DOUGLAS FIR

Douglas fir *(Pseudotsuga taxifolia)* is an interesting timber because there is more of it than any other species in the United States, the greater proportion being in the northern Rocky Mountain and Pacific States. With the exception of redwood, Douglas fir trees are larger than any other in our forests; and they are capable of yielding timbers of practically any length and size desired.

The wood of Douglas fir is of medium weight, strength, stiffness, and toughness among the softwoods. It is used for the same general purposes as Southern yellow pine; and specifica-

tions for structural timbers often carry the two woods on the same basis.

More than half of the total output of Douglas fir lumber goes into general building operations and heavy construction. The more important factory uses reported are indicated in Table 80.

TABLE 80

Factory Uses of Douglas Fir

Purpose	Per Cent
Mill Work	87
Tanks and Silos	4
Car Construction	4
Ship and Boat Building	2
Pumps and Wood Pipe	1
Other Uses	2
Total	100

More specifically Douglas fir is used for:

Boats (beams, cabins, decking, finish, frames, keelsons, knees, masts, planking, spars, stems), boxes, bridge timbers, broom handles, car construction, cement pipe jackets, columns, crates, crossarms, decoy ducks, dump cars, elevator equipment, and mission furniture, mirrors, spring frames, tables), fencing, fixtures (backs, counters, facings, shelves), furniture (book cases, cabinets, chairs, cots, couch frames, drawers, kitchen foundry flasks, gutters, hop baskets, interior work (casing, ceiling, finish, flooring, moulding, stair work, veneered doors, wainscoting), ladders, musical instruments, panels, patterns, paving blocks, pulleys, refrigerators, rug poles, saddles, sash and doors, silo and tank stock, slack and tight cooperage, surveyors' stakes, turnery, veneer, vehicles, washing machines, windmill parts, wood stave pipe.

ELM

There are several species of elm in the United States, by far the most abundant being the common or white elm *(Ulmus americana)*. Other

elms are rock or cork elm *(Ulmus racemosa)*; slippery or red elm *(Ulmus pubescens)*; cedar elm *(Ulmus crassifolia)* of the South; and wing elm *(Ulmus alata)*, which is most common in Texas.

White elm is among the lighter of the hardwoods in weight, is not so strong as many of them, and is not very hard. It is, however, a tough, fibrous wood of varied usefulness. Rock elm is heavy, hard, tough, and strong; and ranks next to hickory for many purposes, especially in the line of vehicle manufacture. Slippery elm is somewhat darker in color than white or rock elm, and is about midway between these two woods in mechanical properties. Wing and cedar elm are used for the same general purposes as white elm.

TABLE 81

Factory Uses of Elm

Purpose	Per Cent
Boxes and Crates	29
Furniture and Fixtures	19
Vehicles	14
Woodenware and Novelties	7
Musical Instruments	7
Refrigerators and Kitchen Cabinets	6
Agricultural Implements	3
Trunks and Valises	3
Mill Work	3
Sporting and Athletic Goods	1
Handles	1
Other Uses	7
Total	100

The statistical reports do not distinguish

between the various elms. The combined uses are summarized in Table 81.

Uses reported for white elm are:

Automobile bodies
Automobile doors
Bails
Banana hampers
Baskets
Basket handles
Bicycle rims
Billiard tables
Bobsleds
Boxes
Bushel measures
Cant-hook handles
Canoe-boat bottom boards
Chairs
Chair bottoms
Cheesebox rims
Communion tables
Crating
Cultivators
Doubletrees
Drawstops
Eveners
Fish backs
Flooring
Folding machines
Grapples
Hand sleds
Hoops (coiled)
Hose menders
Hubs
Ice chests
Interior finish
Kitchen cabinets
Ladders
Mission furniture
Pails
Peavy handles
Pews
Pianos
Pikepoles
Potato crates
Power-pump skids
Press racks
Printers' cabinets
Pulpits
Refrigerators
Riddle rims
Roll-paper cutters
Root cutters
Seed cabinets
Shipping baskets
Showcases
Sieve rims
Singletrees
Sleigh runners
Spraying machines
Stone boats
Store fixtures
Tanner liquor logs (pipe)
Toys
Trunks
Tubs
Wall cases
Washboards
Washing-machine parts
Waste baskets
Wheelbarrows
Woven boxes

Rock elm is used in the manufacture of:

Agricultural implements
Automobile bodies and seats
Bails
Bentwood
Boxes
Crating

Doubletrees (plow and harrows)
Dowels
Eveners (plow and harrow)
Feed cutters
Handles
Hay loader parts
Hounds (vehicles)
Hoppers
Horizontal bars
Hubs (light vehicle wheels)
Interior finish
Ladders
Machine handles
Platforms
Posts (seat)
Rims (trucks)
Rockers (chairs)
Singletrees
Sleigh runners and bodies
Stirrups
Trunks
Trunk slats
Wheelbarrows

EUCALYPTUS

The eucalyptus family is a native of Australia. A number of species were early introduced into California, and more recently considerable plantations of eucalyptus have been established in that State. The one commonly planted is the blue gum *(Eucalyptus globulus),* although the wood of this species is said to have fewer desirable qualities than that of some other less widely planted eucalyptus.

Eucalyptus wood is generally very hard, heavy, tough, and strong, even surpassing hickory in some respects. However, it is much more difficult to season without serious warping and checking than is any other wood used in this country. Much of this difficulty is apparently due to the fact that practically all the eucalyptus lumber so far manufactured in the United States is necessarily produced from young trees of extremely rapid growth. The wood of the large, mature, native Australian eucalyptus is

said to work much better than that from the young planted trees in this country.

Unfortunately, unscrupulous promoters whose object has been to sell stock in eucalyptus companies have disseminated a vast amount of misleading information about the properties of the wood and the fabulous returns to be expected from eucalyptus plantations. Only a small amount of eucalyptus lumber is manufactured, and the uses for it are chiefly as shown in Table 82.

TABLE 82

Factory Uses of Eucalyptus

Purpose	Per Cent
Ship and Boat Building	80
Vehicles	12
Agricultural Implements	3
Furniture	2
Mill Work	1
Machine Construction	1
Other Uses	1
Total	100

FIR

Under this heading are grouped the true firs of the botanical genus *Abies*. Douglas fir, which is known by a wide variety of names, is a distinct genus, and not a fir at all; neither does it have much in common with the true firs since it is much heavier and stronger than these woods.

Of the various true firs, the most important

TABLE 88

Factory Uses of Fir

RED FIR

Purpose	Per Cent
Boxes and Crates	72
Mill Work	28
Total	100

ALPINE FIR

Purpose	Per Cent
Boxes and Crates	62
Mill Work	33
Excelsior	3
Other Uses	2
Total	100

BALSAM FIR

Purpose	Per Cent
Boxes and Crates	76
Mill Work	20
Car Construction	1
Refrigerators and Kitchen Cabinets	1
Woodenware and Novelties	1
Other Uses	1
Total	100

WHITE FIR

Purpose	Per Cent
Mill Work	72
Boxes and Crates	27
Other Uses	1
Total	100

are the balsam fir *(Abies balsamifera)* of the Northern States; the white fir *(Abies concolor)* of the Rocky Mountain and Pacific Coast region; the Alpine fir *(Abies lasiocarpa)*, which grows in high altitudes in the Western mountains; the

noble fir *(Abies nobilis)*, which is most abundant in Oregon; and the red fir *(Abies magnifica)* of California. The balsam fir of the East, and the Alpine fir of the West, are small trees of very similar character. The white, noble, and red firs are among the large trees of the regions in which they are found. The wood of all the firs is very light in weight, soft, not strong, brittle, and even-grained, with no great variations in texture. The firs are not largely sawed at present. Fir lumber is chiefly used for boxes and crates, for which purpose the light weight and softness especially fits these woods. The firs also furnish much material for wood pulp.

So far as reported, the factory uses of the firs are summarized in Table 83.

The noble fir is used for the same general purposes as are the other true firs.

Uses reported for balsam fir include:

Boxes
Boxes (herring)
Cases
Cases (packing)
Cases (sardines)
Ceiling
Clapboards
Cloth boards
Crates
Dairy supplies
Flooring
Frames (door)
Frames (window)
Ironing-table tops
Molding
Refrigerators
Sash
Sheathing
Shooks
Siding
Suit-case frames
Trim

BLACK GUM

Black gum *(Nyssa sylvatica)*, although generally called "gum," is in no way related botanic-

ally to red gum. It is a member of the same genus as tupelo, and much of it is included in the statistics of that wood.

Black gum is somewhat heavier than red gum. The wood is moderately strong and stiff, tough, and very difficult to split—properties which are often desirable. Separate uses reported for black gum are in the manufacture of:

Baskets
Berry cups
Boxes
Conduits
Chucks
Hoppers
Hubs
Keels
Lard dishes
Mauls
Mine rollers
Paving blocks
Ox yokes
Reshippers (bottle crates)
Rollers (boats)
Rug poles
Table legs
Veneer barrels

RED GUM

Red gum *(Liquidambar styraciflua)* is one of the softer hardwoods of medium weight and strength. It has a good figure and a reddish heartwood that make it useful for many purposes. Red gum works easily and is fairly tough; so the lower grades are in large demand for boxes and crates; while the figured wood, properly stained, gives perhaps the closest duplication of circassian walnut obtainable with any timber. Stained differently, red gum is also much used to give mahogany effects.

In addition to being the wood most largely used for slack barrel staves and heading, the statistical reports give the information embodied in Table 84, upon the other factory uses of red gum.

TABLE 84

Factory Uses of Red Gum

Purpose	Per Cent
Boxes and Crates	50
Mill Work	15
Furniture and Fixtures	15
Vehicles	3
Pulleys and Conveyors	2
Sewing Machines	2
Refrigerators and Kitchen Cabinets	2
Agricultural Implements	1
Musical Instruments	1
Woodenware, Novelties, etc.	1
Picture Frames and Moldings	1
Other Uses	7
Total	100

Red gum and sap gum (the sapwood of red gum) enter to some extent into the manufacture of the following articles:

Alfalfa grinder parts
Ballot boxes
Barrels (veneer)
Baskets (fruit)
Baskets (vegetable)
Berry cups
Bookcases (exterior work)
Bottom boards (piano)
Bottoms (heavy vehicle seats)
Boxboards (dump carts)
Boxes
Boxes (delivery wagons)
Boxes (veneer)
Boxes (wire bound)
Box shooks
Brush blocks
Cabinets
Carvings
Caskets
Casing
Cattle guards (railway cars)
Chair frames (upholstered furniture)
Chairs
Chairs (folding)
Chairs (kitchen)
Chairs, official (lodge furniture)
Chairs (parlor)
Cheese boxes
China closets (extension)
Cigar boxes
Cigar wheels (wheel-of-chance)
Coffee drums
Columns (porch)
Commodes
Consoles
Cooperage stock (slack)
Cooperage stock (tight)
Corn graders
Cradles
Crates (fruit and vegetable)

Crating
Cultivator handles
Cupboards (backing)
Cupboards (kitchen)
Curtain poles
Desks (house)
Desks (office)
Dining tables
Drawer bottoms
Dressers (exterior)
Egg cases
Elevator cars
Eraser blocks (blackboard)
Fanning mills
Faucets
Fixtures (bank)
Fixtures (soda fountains)
Fixtures (store and office)
Flour mills (machinery parts)
Folding beds
Frames (couches)
Frames (davenports)
Frames (lounges)
Furniture (exposed)
Furniture (interior work)
Game traps
Grain weighers
Guitar bodies
Handles
Handrails (stairwork)
Hay-baler parts
Hobby horses
Interior finish
Ironing boards
Kitchen cabinets
Kitchen cabinets (backing)
Lawn swings
Legs (incubator)
Library cases
Lining (inside coat boxes)
Litter carrier parts
Manure spreaders
Mop handles
Moldings (piano)
Music cabinets (exterior)
Neck yokes (cultivator)
Ornaments (furniture)
Packages (vegetable)
Panels (light vehicle bodies)
Panels (veneered)
Parlor cabinets (inside work)
Pedestals
Pens
Piano benches
Picture moldings
Posts (stairworks)
Reed organs (interior parts)
Reed organs (exterior)
Refrigerators
Reshippers (boxes)
Rims (guitars)
Runners (sleighs and sleds)
Saddletrees
Sandboards (heavy vehicles)
Scale parts (platform scale)
Screen doors
Seats (water closets)
Seed-cleaner parts
Self-feeders (threshing machines)
Sewing machine parts
Sideboards (built in)
Sideboards (exterior work)
Sideboards (interior work)
Signs (advertising)
Singletrees (cultivators)
Small gun stocks
Sofa frames (upholstered furniture)
Spigots
Stepping (stairwork)
Tables
Tables (extension)
Tables (kitchen)
Tables (library)
Tabourets
Tanks (water closets)
Thresher parts
Tight cooperage stock

Trimmings (piano)
Trunks
Type cabinets
Vane slats (windmill)
Vehicle bottoms
Vending machines
Vending machines (matches)
Veneer cores
Veneer doors
Wardrobes (exterior work)
Wardrobes (interior work)
Washboards (laundry)
Washing machine parts
Weather strippings
Wheel slats (windmill)
Window screens
Woodenware

HACKBERRY

Hackberry *(Celtis occidentalis)*, although not an abundant forest tree, has a wide range; and small quantities are manufactured into lumber and also into cooperage. The wood is heavy, moderately hard, strong, and tough. In properties it is most like white elm, while in appearance the lumber resembles ash.

Statistical reports do not distinguish between the ordinary hackberry and the Southern form or sugarberry *(Celtis mississippiensis)*.

TABLE 85

Factory Uses of Hackberry

Purpose	Per Cent
Mill Work	39
Boxes and Crates	28
Woodenware and Novelties	13
Vehicles	9
Furniture and Fixtures	7
Saddles and Hames	4
Total	100

Specific uses reported for hackberry include:

Buggy bodies, cart trees, farm implements, handles, furniture, hoe handles, interior finish, kegs, rakes, saddle trees, stair rails, steps, table legs and tops, tubs, wagon parts.

The Louisiana factories use sugarberry for:

Car finish, furniture, railing, slack cooperage, stair steps, table frames, tool handles, and vehicle bodies.

HEMLOCK

Commercially, there are two important species of hemlock—the Eastern hemlock *(Tsuga canadensis)*, which is most abundant in the Lake States, West Virginia, Pennsylvania, New York, and New England; and Western hemlock *(Tsuga heterophylla)*, the largest stands of which are in the Pacific Northwest.

The Eastern hemlock is among the lighter woods in weight, fairly stiff and strong, and tougher than most softwoods. The Western hemlock is heavier, stronger, and stiffer than the Eastern, and, in mechanical properties, rather closely approaches Douglas fir. A large proportion of the hemlock lumber goes directly from the sawmill into general building operations.

Without distinction between species, the

TABLE 86

Factory Uses of Hemlock

Purpose	Per cent
Mill Work	62
Boxes and Crates	29
Car Construction	2
Furniture	1
Trunks and Valises	1
Refrigerators and Kitchen Cabinets	1
Other Uses	4
Total	100

reports indicate the factory uses of hemlock as given in Table 86.

More specifically, Eastern hemlock enters into the manufacture of the following articles:

- Bakers' machinery
- Beamboxes (weighing machines)
- Boat parts
- Boxes
- Car decking
- Car doors
- Crating
- Flasks
- Flooring
- Ice boxes
- Interior finish
- Pails
- Piano boxes
- Portable farm forges
- Refrigerators
- Sash
- Seed boxes (machines)
- Shop patterns (boats)
- Siding
- Signs
- Silos
- Tobacco cases
- Trunks
- Tubs
- Vehicles
- Washboards
- Well machine parts
- Window frames

According to the Oregon and Washington reports, Western hemlock is used on the Pacific Coast for:

Boat finish, boxes, caskets, cooperage, crates, fixtures (drawers, shelves), furniture (backing, couches, kitchen table tops), interior work (casing, ceiling, finish, flooring, moulding, wainscoting), pulp, sash and doors, screens and veneer.

HICKORY

There are a number of species of hickory; but those of greatest commercial importance are five, as follows: Shellbark *(Hicoria laciniosa)*, shagbark *(Hicoria ovata)*, mockernut *(Hicoria alba)*, bitternut *(Hicoria minima)*, and pignut *(Hicoria glabra)*. The pecan *(Hicoria pecan)* is also a hickory, and is used to some extent for the same purposes as the other species.

The hickories, with the exception of black locust and osage orange, are the heaviest, strongest, and toughest of our native woods. It is the remarkable toughness of hickory, and its ability to withstand shocks, that make it the wood above all others for vehicle work.

All the hickories are used in the manufacture of vehicles, handles, and other articles where strength and toughness are the main consideration; but pignut perhaps possesses these properties in greater degree than any of the other species.

The factory uses of hickory are indicated in Table 87.

TABLE 87

Factory Uses of Hickory

Purpose	Per Cent
Vehicles	61
Handles	31
Agricultural Implements	3
Sporting and Athletic Goods	1
Other Uses	4
Total	100

A great deal of hickory, instead of being manufactured into lumber, goes in bolt form directly to the factory in which it is to be fashioned into some useful article. According to the reports, hickory enters more or less into the construction of:

Agricultural implements
Axles (light vehicles)
Baskets
Baseball bats
Binder parts
Board rules

Bottoms (wagon boxes)
Brake bars
Cabinet work
Calking hammers
Canes
Car repairing
Car construction
Carvings
Chairs
Corn binder parts
Crossbars (light vehicles)
Crutches
Cultivator handles
Doubletrees
Dowels
Eveners (farm implements)
Felloes
Freight cars
Gear woods (light vehicles)
Golf sticks (handles)
Hammer handles
Handles
Handles (broom)
Handles (edge tools)
Hay baler parts
Hay loader parts
Header parts
Hounds (heavy vehicles)
Ladders
Ladder rungs
Log rules
Machinery handles
Mallets
Manure spreader parts
Maul handles
Molds (brick)
Neck yokes (implement)
Neck yokes (plows)
Neck yokes (vehicles)
Patterns
Pike poles
Pins
Picture molding
Picker sticks
Pick handles
Pitmans (farm implements)
Plow beams
Plow handles
Poles (light vehicle)
Rake teeth
Refrigerators
Revolving rakes
Rims (automobile wheels)
Rims (vehicle wheels)
Road-scrapers
Shafts (vehicle)
Singletrees
Sledge handles
Small tool handles
Spokes (automobile)
Spokes (light and heavy vehicles)
Spring bars (light vehicles)
Sucker rods
Threshing machines
Tongues (light vehicles)
Tongues (wagon)
Tongues (wheel scrapers)
Trapeze (gymnasium)
Trucks
Trunk slats
Turnings
Wagon stock
Wagon jacks
Whiffletrees
Windmill rods

HOLLY

Holly *(Ilex opaca)* is a tough, close-grained wood of ivory-like appearance, which makes it especially valuable for inlay work and in the manufacture of many small articles. Since

holly trees are neither large nor abundant, only small quantities of this wood are available. The factory uses reported are indicated in Table 88.

TABLE 88

Factory Uses of Holly

Purpose	Per Cent
Woodenware and Novelties	69
Brushes	24
Musical Instruments	4
Other Uses	3
Total	100

HORNBEAM

Hornbeam or ironwood *(Ostrya virginiana)* is one of the heaviest, hardest, and toughest American woods, ranking very closely to the hickories in these respects. It is not available in such large quantities as the hickories, but is used for much the same purposes, as Table 89 indicates.

Specific uses for hornbeam includes axles, felloes, tongues, levers, canes, umbrella sticks, and whipstocks.

TABLE 89

Factory Uses of Hornbeam

Purpose	Per Cent
Handles	68
Vehicles	21
Mill Work	3
Furniture	2
Woodenware and Novelties	2
Other Uses	4
Total	100

ıking Bicycle Rims of Hard Maple in a New Hampshire Factory

ıccessive Stages in Making Shuttles from Dogwood and Persimmon

Paint-Brush Handles Made from Birch and Maple

ıte 32—Lumber and Its Uses

Interior of a Chair Factory in North Carolina

Boxes, Spools, Shoe Shanks, and Other Articles Made from Paper Birch

Plate 33—Lumber and Its Uses

LARCH

See Tamarack (page 305).

LAUREL

Laurel *(Kalmia latifolia)* is a fine-grained hardwood, produced in small quantities in the Southern mountains. It is nearly as hard as dogwood, and as heavy as white oak. It is not available in large sizes nor in great quantity; but such factory uses as are reported for the small amount consumed are as indicated in Table 90.

TABLE 90

Factory Uses of Laurel

Purpose	Per Cent
Ship and Boat Building	66
Furniture and Fixtures	19
Brooms and Carpet-Sweepers	7
Woodenware and Novelties	6
Other Uses	2
Total	100

The California laurel *(Umbellularia californica)*, or myrtle, is not very abundant, but is used on the Pacific Coast for the manufacture of interior finish, fixtures, furniture, musical instruments, pilot wheels, turnery, and novelties.

LOCUST

There are two native locusts found in the Eastern States—the honey locust *(Gleditsia triacanthos)* and the black locust *(Robinia pseudacacia)*. The honey locust is not abun-

dant, however; and so, while possessing many desirable qualities in the way of strength and hardness, is little used.

Black locust and osage orange closely compete for the honor of being the heaviest and strongest American woods. In other respects they split even, for osage orange is the tougher, and black locust the stiffer. Both shrink less in seasoning than almost any other wood, either hard or soft—which is also an extremely desirable quality.

Black locust finds by far its largest use in the manufacture of insulator pins and brackets, with a small amount used for mill work, in ship and boat building, and for vehicles. In ship and boat building, black locust is valuable for tree nails, for the ancient method of holding two pieces of wood together by means of a wooden pin or nail has, for some purposes, not been improved upon.

TABLE 91

Factory Uses of Locust

Purpose	Per Cent
Insulator Pins and Brackets	90
Mill Work	3
Ship and Boat Building	3
Vehicles	2
Other Uses	2
Total	100

Black locust is also used for patterns, chucks, hubs, turnery, trunnels, and spokes for boat wheels.

Some of the small amount of honey locust manufactured is used in furniture, millwork, balusters, newels, and molding.

MAGNOLIA

Two species of magnolia are cut for lumber to some extent in the Southern States, in addition to the cucumber tree previously mentioned. These are the evergreen magnolia *(Magnolia foetida)* and the sweet magnolia *(Magnolia glauca)* or bay tree. Most of the magnolia lumber, however, is made from the evergreen magnolia.

Magnolia wood is of compact structure, light, soft, easily worked, with a satiny luster, and creamy white to light brown in color. It goes to market with yellow poplar, as well as under its proper name. Such separate factory uses of magnolia as are reported are shown in Table 92.

TABLE 92

Factory Uses of Magnolia

Purpose	Per Cent
Boxes and Crates	88
Furniture and Fixtures	8
Mill Work	2
Tobacco Boxes	1
Other Uses	1
Total	100

More specific uses reported for magnolia include:

Bar fixtures
Bed-room suites
Boats
Boxes
Broom handles
Brushes

Cabinets
Car sheathing
Cotton gins
China closets
Door panels
Dressers
Egg cases
Excelsior
Furniture
Interior finish
Molding
Ox yokes
Sash
Tables
Wagon boxes
Wash stands

MAPLE

Four species of maple are of commercial importance from the lumber standpoint. These are hard or sugar maple *(Acer saccharum)*, red maple *(Acer rubrum)*, soft or silver maple *(Acer saccharinum)*, and Oregon maple *(Acer macrophyllum)*. Hard maple is by far the most abundant and useful member of the group.

The wood of hard maple is of moderate weight for a hardwood, strong, hard, and with good wearing qualities. Variations in structure and appearance due to peculiarities of growth give curly and bird's-eye effects which are much prized. The wood of soft maple is considerably lighter in weight, and not so strong or stiff as that of the hard maple. It has a good figure, and is used for many purposes. Red maple is about midway between hard and soft maple in weight and strength. In hardness, it is close to the soft maple; and in stiffness, not very far from the hard maple. Oregon maple is the only commercial maple on the Pacific Coast, and is the most important hardwood of that region. The wood resembles that of the Eastern maples, and is used for the same general purposes.

Hard maple is the maple used in the manufacture of hardwood flooring and wherever strength and resistance to wear are the determining qualities.

In the wood-using industry reports, all the maples are grouped together with results shown in Table 93.

TABLE 93

Factory Uses of Maple

Purpose	Per Cent
Mill Work	34
Furniture and Fixtures	17
Boxes and Crates	10
Boot and Shoe Findings	6
Agricultural Implements	5
Musical Instruments	5
Handles	4
Woodenware, Novelties, etc.	4
Vehicles	4
Laundry Appliances	2
Other Uses	9
Total	100

These specific uses reported for hard maple indicate the great serviceability of this wood:

Automobile benches
Automobile bottoms
Automobile gears
Automobile sub-floors
Axles
Baggers
Baseball bats
Baskets
Bean pickers
Bicycle rims
Billiard cues
Billiard rings
Blueprint frames
Bobbins
Bobsleds
Bolsters
Bowling alleys
Bowls
Boxes
Bread boards
Brewers' chips
Broom handles
Brush backs
Brush handles
Built-up panels
Butcher blocks

Butter boxes
Butter ladles
Butter molds
Cameras
Canes
Cant-hook handles
Car-gallows frames
Carpet-sweepers
Carrom cues
Carrom rings
Caster rollers
Cattle guards
Center wheels
Chair bottoms
Chair rods
Checkers
Churn dashers
Clothespins
Coat hangers
Coil bases (telephone)
Corn huskers
Corn planters
Corn shellers
Costumers
Cot frames
Cranes
Croquet balls
Croquet mallets
Culm pipe (mines)
Cultivator handles
Curtain poles
Dashboards
Die blocks
Die cases
Dishes
Dominoes
Door knobs
Dowels
Drawer bottoms
Dumb-bells
Electrotype blocks
Ensilage cutters
Extension stretchers
Factory trucks
Faucets
Feed cutters
Feeders
Flooring
Furniture
Games
Gas-engine skids
Girts
Go-carts
Grain doors
Grain separators
Grills
Guitars
Hand cars
Handles
Handspikes
Hay balers
Hay pressers
Hoop drums
Horizontal bars
Hose menders
Indian clubs
Interior finish
Kitchen cabinets
Knobs (furniture)
Kraut cutters
Ladders
Lasts
Lemon squeezers
Levers
Log cars
Mallets
Mandolins
Mangle rollers
Manual training supplies
Manure spreaders
Meat boards
Medicine cabinets
Mission furniture
Office fixtures
Packing-house cutting tables
Paddles
Pails
Paper cutters

Parasol handles
Parquetry floors
Patterns
Peavy handles
Pianos
Piano bridges
Piano pin planks
Piano players
Plow beams
Plugs
Plumbers' woodwork
Porch swings
Portable sawmills
Potato mashers
Potato planters
Pulley spokes
Pumps
Push cars
Racks
Railroad velocipedes
Reed furniture (rods)
Refrigerators
Riddles
Road rollers
Roller pins
Rules
Sawmill machinery
Scythe snaths
Self feeders
Separators (grain)
Sheeting
Showcases
Shredders
Skewers
Sleighs
Spindles
Spoke wedges
Spool barrels
Spoons
Steak mauls
Steering wheels
Stonecutters' mallets
Stone boats
Store fixtures
Switch boards
Table rims
Talking machines
Tanks
Tanning drums
Tenpins
Threshing machines
Thresholds
Tie plugs
Timber grapples
Tinners' mallets
Tin-plate boxes
Toothpicks
Towel racks
Toys
Track gauges
Track levels
Trucks
Trunks
Tubs
Type cabinets
Type cases
Umbrella racks
Wall cases
Wall clocks
Washboards
Washing machines
Weighing machines
Wheelbarrows
Wind stackers
Wooden bearings
Wood knobs (grilles)
Woodtype
Yardsticks

Soft maple is used in the manufacture of:

Auto frames
Baby carriages
Ballot boxes
Berry baskets
Boats
Bookcases

Boxes
Brooders (poultry)
Broom handles
Butter bowls
Carpet sweepers
Chairs
Coat hangers
Corn planters
Cot frames
Cradles
Cultivators (garden)
Door frames
Egg cases
Extension-table sides
Fanning mills
Filing cabinets
Fixtures
Flooring
Furniture
Grass seeders
Hall clocks
Hand sleds
Hay racks
Ice boxes
Incubators
Interior finish
Ironing boards
Kitchen cabinets
Knobs (furniture)
Lap boards
Lawn swings
Manual training supplies
Music cabinets
Office fixtures
Parquet floors
Pianos
Piano benches
Pumps
Potato planters
Reels (wire)
Refrigerators
Root cutters
Signs
Sleeve boards
Table tops
Tabourettes
Tin-plate boxes
Umbrella racks
Vehicles
Velocipedes, railroad
Wardrobes
Woodenware

Oregon maple is used on the West Coast for baskets, boat finish, building rollers, dollies, fixtures (counter tops, grill work, mirror frames, show cases), furniture (bookcases, chairs, davenport frames, school furniture, spindles, tables), handles, interior work (finish, flooring), pulleys, saddles, tent toggles, and trunk slats.

OAK

Botanists recognize some fifty species of oak in the United States, all but a few of which attain tree size, while many are among the larg-

est and finest hardwoods. With such a wealth of species, it is impossible to get statistics upon the consumption of the separate kinds with any degree of accuracy. Moreover, most of the oak is marketed under the general names of "white oak" or "red oak," without further specific distinction.

Of the white oak group, the most important are the true white oak *(Quercus alba)*, bur oak *(Quercus macrocarpa)*, post oak *(Quercus minor)*, cow oak *(Quercus michauxii)*, chestnut oak *(Quercus prinus)*, overcup oak *(Quercus lyrata)*, and Oregon oak *(Quercus garryana)*. Of the red oak group, the most useful species are the true red oak *(Quercus rubra)*, Texan oak *(Quercus Texana)*, chinquapin oak *(Quercus acuminata)*, yellow oak *(Quercus velutina)*, scarlet oak *(Quercus coccinea)*, turkey oak *(Quercus catesbaei)*, Spanish oak *(Quercus digitata)*, pin oak *(Quercus palustris)*, shingle oak *(Quercus imbricaria)*, and willow oak *(Quercus phellos)*. The white and red oak groups supply about equal amounts of lumber. Two other important species which belong to neither group are live oak *(Quercus virginiana)* and California tanbark oak *(Quercus densiflora)*.

The wood of nearly all the oaks is heavy, hard, strong, and tough, with the characteristic figure which has always made oak a standard cabinet, furniture, finish, and flooring wood, in addition

Altars (church)
Art lamps
Axe handles
Backgrounds (display windows)
Ball racks (pool and billiard)
Balusters
Barber chairs
Barber furniture
Bar fixtures
Bars (wooden harrows)
Baseboards
Basket parts
Beams (plow)
Beds
Beds (cot)
Beds (folding)
Billiard (tables)
Binder parts
Boat parts (row)
Bobsleds
Bolsters (heavy vehicles)
Bookcases
Book racks
Bottoms (baggage trucks)
Bottoms (delivery wagons)
Braces (railway car frames)
Brackets
Brake beams (heavy vehicles)
Brush blocks
Buffets (exterior)
Bumping posts (railroad)
Butter churn bodies
Butter churn bottoms
Cabinets (dental)
Cabinets (filing)
Cabinets (music rolls)
Cabinets (parlor)
Cabinets (phonograph records)
Cabinets (toilet)
Cabinets (towels)
Cabins (boats)
Capitals
Card tables
Cases (medicine)
Cases (railroad ticket)
Casing
Caskets
Chair frames
Chairs
Chairs (adjustable)
Chairs (invalid)
Chairs (office)
Chairs, official (lodge room)
Chairs (rolling)
Chairs (stenographers)
Cheval mirrors
Chiffoniers
China closets
Church pews
Cigar wheels (wheel-of-chance)
Clay gatherers (machine parts)
Cleats (wagon boxes)
Coffins
Colonnades
Columns (porch)
Consoles
Cores (veneer doors)
Corn binders
Corn grinders
Costumers
Couches (folding)
Counters (bar)
Counters (store)
Cradles
Cue racks (pool and billiard)
Cultivator handles
Desks (electric switchboards)
Desks (house)
Desks (office)
Disc drill parts
Disc harrow parts
Door frames (Ry. box cars)
Doors
Doubletrees (farm implements)

Parlor rockers
Parquetry flooring
Passenger cars (frames)
Passenger cars (interior finish)
Pedestals
Pedestals (tables)
Pew racks
Piano benches
Piano cases
Piano chairs
Piano players (exterior)
Piano stools
Pick handles
Picture moldings
Pilasters (piano)
Plate racks
Plow beams
Plow handles
Plow rounds
Plow parts (gang)
Plows
Poles (light vehicles)
Pool tables
Posts (railway car frames)
Posts (stairwork)
Pulpits (church)
Racks (hat and coat)
Reaches (heavy vehicles)
Reels (electric light wire)
Refrigerators
Revolving chairs (office)
Revolving chairs (parlor cars)
Rims (heavy vehicle wheels)
Risers (stairwork)
Road-scrapers
Rocker frames (upholstered furniture)
Sand boards
Sash
Screen doors
Seats (water closets)
Sections (wheel-scrapers)
Seeder parts (farm implements)
Serving tables
Sewing tables
Shanks (cultivators)
Shells (drum)
Sideboards (built in)
Sideboards (exterior)
Siding (boats)
Sills (threshers)
Singletrees (cultivators)
Singletrees (vehicle)
Sleds (toy)
Sofa frames (upholstered furniture)
Somnols
Spokes (heavy vehicles)
Spring bars
Spring blocks (Ry. tank cars)
Stacker parts (farm machinery)
Stands
Stands (jardinieres)
Stands (lamps)
Staves (water tanks)
Steps (stairwork)
Stringers (railway cars)
Subscriber sets (telephone)
Sulky plow parts
Sweeps (farm machinery)
Sweeps (windmills)
Switchboards (telephone and telegraph)
Tables (cafe)
Tables (dining)
Tables (extension)
Tables (library)
Tables (parlor)
Tables (typewriter)
Tables (writing)
Tabourets
Tanks (brewery)
Tanks (distilling)
Tanks (water closets)
Telephones
Threshing machines
Tight cooperage stock

Tongues (wheel-scrapers)
Tool chests
Tool handles
Trays (jewelry)
Type (cabinets)
Typewriter cabinets
Umbrella stands
Vats (distilling)
Vats (oil)
Vending machines (matches)
Vending machines (peanuts)
Vestment cases (church)
Wagon boxes
Wainscoting
Wall cases
Wardrobes (exterior)
Washstands
Water gates
Water wheels
Well-digging machines
Windmill parts
Window screens

The red oaks are used in the manufacture of:

Agricultural implements
Art lamps
Back grounds
Balusters
Barber furniture
Barrow boxes
Baskets
Beds
Bentwood
Billiard tables
Boats
Bob sleds
Bolsters
Bottoms (wagon)
Boxes
Brackets
Brake bars
Bucket staves
Buggy bows
Cabinets
Cabin parts
Car construction
Cars (mine)
Car repairing
Casing (building)
Caskets
Chair frames (upholstered furniture)
Chairs
Chairs (office)
Chair stock
China closets
Church pews
Clocks
Clothes props
Corn shellers
Cornices
Crating
Cultivator handles
Decking
Disc harrow parts
Doors
Double doors (farm implements)
Drags (farm implements)
Dressers
Dressing tables
Elevator flooring
Eveners (farm implements)
File cases
Fixtures (bank)
Fixtures (barber shop)
Fixtures (display window)
Fixtures (soda fountain)
Flooring (hardwood)
Flag staffs
Folding beds
Folding machines
Frames (couches)
Frames (davenport)
Frames (light and heavy vehicle bodies)

Frames (upholstered parlor furniture)
Furniture
Hallracks
Hay-loader parts
Interior finish
Kitchen cabinets (exterior)
Laundry appliances
Lodge furniture
Mantels
Manure spreaders
Mission furniture
Molding (stairwork)
Organ (pipe) cases
Organ actions
Organs
Parquetry flooring
Patterns
Piano benches
Piano cases
Piano parts
Piano stools
Piano tops
Picture molding
Planing mill products
Platforms (stairwork)
Plow beams
Plow handles
Plow parts (gang)
Plow rounds
Plumbers' woodwork
Pokes (animal)
Porch work
Refrigerators
Rocker frames (upholstered furniture)
Sash
Sheathing
Showcases
Sideboards (built in)
Sideboards (exterior work)
Signs
Sling crossbars
Stirrups
Sulky plow parts
Table legs
Tables (extension)
Tables (library)
Tables (writing)
Tabourets
Tanks (water closets)
Trucks
Toys
Vehicles
Veneer
Wainscoting
Washstands
Woodenware

Oregon oak is used on the Pacific Coast in place of both white and red oak from the East, and especially for baskets, boats (frames, interior, finish, keels, ribs, sills), fixtures, furniture (cabinets, chair stock, table tops), handles, interior work, insulator pins, saddles, and wagons.

The tanbark oak of California is an important source of tanbark in that State. It has not been much used for lumber so far; but, with the methods of cutting and seasoning adapted to a

hardwood, it will prove useful for many purposes.

OSAGE ORANGE

Osage orange *(Toxylon pomiferum)* is the heaviest, hardest, and toughest American wood so far tested; but in strength and stiffness it is somewhat surpassed by black locust. It is one of the most durable woods, and fence-posts of it give very long service. Because of the poor form of the tree and its rarity in native condition, except in a rather limited region in Oklahoma and Texas, not much osage orange lumber is produced. The largest use is for wagon felloes for service in arid regions. Osage orange is especially adapted to this purpose, because of the very small amount which it shrinks and its great toughness.

Such factory uses as are reported for osage orange are summarized in Table 95.

TABLE 95

Factory Uses of Osage Orange

Purpose	Per Cent
Vehicles	84
Woodenware and Novelties	9
Car Construction	6
Other Uses	1
Total	100

Osage orange is also used to some extent for canes, clock cases, furniture parts, insulator pins, hubs, inlaid work, and mauls.

Bringing in the Logs

Unloading Logs at the Mill

Hauling White Cedar Posts in Winter

Dinner Time at Camp

Good Train Load of Logs

TYPICAL LUMBERING SCENES

Plate 34—Lumber and Its Uses

A Well-Kept Lumber Yard

A Typical Sawmill

Poorly Piled Lumber

Poorly Piled Lumber

Well-Piled Lumber

Good Foundations for Lumber Piles

Plate 35—Lumber and Its Uses

PERSIMMON

The persimmon *(Diospyros virginiana)* is a member of the ebony family; and its dark heartwood resembles ebony in being very heavy, hard, and strong. Persimmon wood is very fine-grained, takes a high polish, and is extremely resistant to wear. For this reason, persimmon finds its largest use in the manufacture of shuttles, along with dogwood. The process of manufacture for the latter is illustrated in Plate 32.

The reported uses of persimmon are indicated in Table 96.

TABLE 96

Factory Uses of Persimmon

Purpose	Per Cent
Shuttles	82
Boot and Shoe Findings	11
Sporting and Athletic Goods	6
Other Uses	1
Total	100

PINE

The pines are found to some extent in almost every forest region, and, in total number of species, are as numerous as the oaks. They furnish nearly half of the annual lumber supply.

There are two large groups of pines, as there are two main groups of oaks. These are the white pines and the yellow pines. Aside from the common white pine *(Pinus strobus)*, of which more lumber has so far been manufac-

tured than of any other species in the United States, other important members of the white pine family are Western white pine *(Pinus monticola)*, which is most abundant in western Montana and northern Idaho; and sugar pine *(Pinus lambertiana)*, of the Sierra region of California and southern Oregon.

In the yellow pine group are longleaf pine *(Pinus palustris)*, shortleaf pine *(Pinus echinata)*, loblolly pine *(Pinus taeda)*, and Cuban pine *(Pinus heterophylla)*, of the South; pitch pine *(Pinus rigida)*, which occurs both north and south in the Eastern States; Norway or red pine *(Pinus resinosa)*, of New England and the Lake States; jack pine *(Pinus divaricata)*, of the Lake States; lodgepole pine *(Pinus contorta)*, of the Rocky Mountain region; and Western yellow pine *(Pinus ponderosa)*, from the Black Hills to the Pacific Coast.

There are so many trade names applied to the pines without distinction of species that the reader is often confused. Much of the Southern pine goes to market simply as yellow pine; but the loblolly pine of the North Carolina-Virginia district is called "North Carolina pine," while "Georgia pine" is a time-honored term for the longleaf pine of that State. "Arkansas soft pine" is a trade designation for the shortleaf pine of Arkansas. Some of the white pine and Norway pine in the Lake States is sold under the common name of "Northern pine." Western yellow pine is marketed under a variety

TABLE 97

Factory Uses of Pine

WHITE PINE

Purpose	Per Cent
Mill Work	49
Boxes and Crates	36
Car Construction	2
Matches	2
Rollers, Shade and Map	2
Woodenware, Novelties, etc.	1
Caskets and Coffins	1
Other Uses	7
Total	100

SOUTHERN YELLOW PINE

Mill Work	75
Boxes and Crates	12
Car Construction	8
Agricultural Implements	1
Other Uses	4
Total	100

SUGAR PINE

Mill Work	55
Boxes and Crates	40
Musical Instruments	2
Other Uses	3
Total	100

WESTERN YELLOW PINE

Boxes and Crates	51
Mill Work	47
Other Uses	2
Total	100

of names; but the most common designation, aside from "California white pine," is simply "Western pine," the term applied in the Montana-Idaho-Washington region.

As will be seen from the comparisons in the chapter on properties of wood, the weight, strength, stiffness, and toughness of the pines are as varied as are the numerous species. The white pines are light in weight, soft, even-grained, and easily worked, being in this respect much like the spruces and cedars. Longleaf pine is the heaviest, hardest, strongest, stiffest, and toughest softwood, and, in these properties, ranks ahead of a number of the hardwoods. Between white pine and longleaf pine, the other pines offer almost every gradation in properties.

All of the pines are largely in demand for general building purposes. In addition to these, the statistical reports furnish the data summarized in Table 97 as to the factory uses of white pine, sugar pine, Western pine, and Southern yellow pine, the latter being made without reference to species.

The varied usefulness of the pines is still further indicated by reports of their consumption in the manufacture of the following articles:

WHITE PINE

Agricultural implements
Actions (organ)
Actions (piano)
Actions (piano players)
Automobile bodies
Balusters (porch)
Barrel-starchers (laundry)
Beehives

Bellows (blacksmith)
Bellows (reed organs)
Blinds
Boat parts (row)
Bookcases (inside)
Bottoms (wagon boxes)
Bottoms (water tanks)
Boxes
Boxes (organ)
Boxes (piano)
Boxes (yeast)
Box shooks
Brackets (cornice)
Brackets (porch)
Brooders (poultry)
Buckets
Cabin parts (boats)
Cabinet work (unexposed)
Capitals
Cases (beer bottles)
Cases (milk bottles)
Cases (railroad tickets)
Cases (piano parts)
Caskets
Casting patterns
Chests (organ)
China cases (inside work)
Clocks
Coffins
Columns (porch)
Coops (poultry)
Covers (door panels)
Cores (tin-clad doors)
Cornices
Corn shellers
Couches (box)
Crating
Cupolas (foundry)
Deadwood (tank towers)
Desks (tank towers)
Door frames
Doors
Elevator guide posts
Elevator platforms
Feed mills
Fixtures (barroom)
Fixtures (soda fountain)
Flooring (motor boats)
Foundry flasks
Frames (couches)
Frames (davenports)
Frames (lounges)
Freight cars
Furniture (inside)
Girdles
Grain doors
Grain elevators
Horizontal folding doors
Incubators
Insulation (Ry. refrigerator cars)
Interior finish
Keys (piano)
Kitchen cabinets
Ladders
Launch parts
Laundry machines (hydraulic)
Linings (Ry. box cars)
Log-car templates
Matches
Molding
Office fixtures
Pails
Passenger cars
Patterns
Pharmaceutical packing cases
Picture frames
Planking (boats)
Porch columns
Portable farm forges
Pumps
Refrigerators
Saddlery cutting boards
Sash
Shredders
Siding
Silos

Bottoms (light vehicles)
Boxboards (dump carts)
Boxboards (wagons)
Boxes
Box shooks
Brackets (cornice)
Brackets (interior trimmings)
Brackets (porch)
Cabinets (dental)
Cabinets (jewelry)
Cabinets (toilet)
Cabinet work
Capitals
Car sills
Cases (china)
Cases (medicine)
Casing
Ceiling
Climbing poles (gymnasium)
Cold storage rooms
Colonnades
Columns (porch)
Consoles
Cores (veneer doors)
Cores (veneer panels)
Corn husker parts
Corn pickers
Cotton pickers
Covers (water tanks)
Cradles (tank cars)
Cranes (flooring)
Crating
Cultivator parts
Decking (freight cars)
Decks (boats)
Derrick beams
Disc harrow parts
Display racks (rugs)
Door frames
Doors
Doors (railway box cars)
Drill boxes (farm implements)
Elevator guide posts
Elevators
Eveners (harrows)
Feed mills
Finish (boats)
Fixtures (laboratory)
Fixtures (office, cafe)
Flag poles
Flasks
Flooring
Flooring (freight cars)
Flooring (railway refrigerator cars)
Flooring (scale platforms)
Frames (box cars)
Frames (motor boat hulls)
Frost boxes (windmills)
Gears (heavy wagons)
Grain elevators
Grille work
Hand cars
Handrails (stairwork)
Hayloader parts
Hay presses
Hayracks
Hayrake parts
Head blocks (tank cars)
Header parts
Hydraulic jacks (parts)
Ice boxes
Interior finish
Ladders (extension)
Ladders (step)
Lawn swings
Linings (box cars)
Linings (incubator bodies)
Mantels
Moldings (interior finish)
Neck yokes
Needle beams (railway car frames)
Newels (stairwork)
Ornaments (furniture)
Panels (veneered)
Passenger cars (frames)
Pianos (interior work)

Pickets (fence)
Picture moldings
Platforms (tank towers)
Plow parts (gang)
Poles (farm implements)
Poles (wagons)
Posts (stairwork)
Pump rods (windmills)
Railway motor car parts
Railway push cars
Refrigerators
Risers (stairwork)
Road machinery
Road tools
Roofing (box cars)
Screen doors
Seats (water closets)
Seed-corn driers
Seeder boxes (farm implements)
Shoveling boards (farm wagons)
Sideboards (built in)
Side plates (railway freight cars)
Siding (box cars)
Signboards
Signs (advertising)
Sills (railway cars)
Silos
Skids (engine)
Slats (railway cattle cars)
Stacker parts (farm machinery)
Steps (stairwork)
Stringers (railway cars)
Sulky plow parts
Sweeps (feed mills)
Sweeps (water tanks)
Tackle blocks
Tanks (acid)
Tent poles
Threshing machines
Tobacco cases
Tongues (binders)
Tongues (cotton planters)
Tongues (manure spreaders)
Tongues (plows and cultivators)
Tongues (wagons)
Wagon dumps
Wainscoting
Washing machines (hand)
Washing machines (hydraulic)
Well-digging machines
Window frames
Windmills

LOBLOLLY PINE

Agricultural implements
Balusters
Baseboards
Basket Bottoms
Blinds
Boat construction
Boxes
Boxes (coffee)
Boxes (dry goods)
Box shooks
Cabbage crates
Cabinets
Car decking
Car siding
Casing
Ceiling
Clapboards
Coffins
Conduits
Cornices
Crating
Cross-arms
Decking (freight cars)
Doors
Door frames
Dunnage (freight cars)

Excelsior
Fixtures
Furniture backs
Furniture (veneer cores)
Flooring
Flooring (factory)
Flooring (freight car)
Grain doors
Interior trim (house)
Kitchen cabinets
Ladders
Landing posts
Lining (freight cars)
Moldings
Newel posts
Outer cases (casket)
Panels (furniture sides)
Partition
Pilasters
Poultry coop (bottoms)
Refrigerators
Roofers
Sample cases
Sash
Screens (door)
Screens (window)
Siding
Siding (freight cars)
Silos
Stair rails
Stairways
Store fronts
Tanks
Trunk boxes
Vehicles
Wagon panels
Wardrobes
Window frames
Wire reelc
Woodenware

Western white pine, sugar pine, and much of the Western yellow pine are used for the same general purposes as Eastern white pine. The first two are true white pines, while the sapwood of the Western yellow pine resembles white pine in several respects.

The uses of shortleaf pine are as numerous and diversified as those listed for longleaf and loblolly pine.

YELLOW POPLAR

Yellow poplar *(Liriodendron tulipifera)* is a light, soft, fine-grained, easily worked durable wood in many respects much like basswood. It has a wide range of usefulness; and, in addition to serving in its own proper form, yellow poplar is also much used as a backing for veneer of other woods.

The factory uses most largely reported for yellow poplar are indicated in Table 98.

TABLE 98

Factory Uses of Yellow Poplar

Purpose	Per Cent
Mill Work	35
Boxes and Crates	24
Furniture and Fixtures	10
Vehicles	7
Musical Instruments	6
Car Construction	5
Bungs and Faucets	3
Agricultural Implements	2
Caskets and Coffins	1
Sewing Machines	1
Woodenware and Novelties	1
Tobacco Boxes	1
Other Uses	4
Total	100

The following list of articles in the manufacture of which yellow poplar is used, gives a still better idea of the varied purposes which this wood serves:

Actions (piano players)
Aeroplanes
Agricultural implements
Automobiles
Backs (washboards)
Barber chairs
Baseboards
Baskets (fruit)
Bevel siding
Billiard tables
Blinds
Bookcases
Bowling alleys
Boxboards (heavy vehicles)
Boxes (veneer)
Box shooks
Brush blocks
Carvings
Cabinets
Car repairing
Car construction
Carpet sweepers
Cart beds
Cases (medicine)
Casing
Caskets
Ceiling
Church furniture
China closets (inside)
Cider mills
Cigar boxes
Churns

Coffins
Cornice
Corn shellers
Costumers
Crates (fruit and vegetable)
Crating
Desks (inside)
Drawer bottoms (furniture)
Doors
Egg cases
Elevators
Elevators (corn)
Evaporator pan sides
Exterior finish
Facia
Feedcutter tables
Fixtures (bank)
Fixtures (bar)
Fixtures (display windows)
Fixtures (laboratory)
Fixtures (store and office)
Flooring
Flour mills (machinery parts)
Frames (couches)
Frames (davenports)
Frames (lounges)
Frames (organ interior)
Frames (upholstered furniture)
Furniture (inside)
Goldleaf work
Guitar bodies
Guitar necks
Handles
Header parts
Hoppers
Interior finish
Ironing-boards
Keels (boats)
Ladders
Laundry machines (hand)
Laundry machines (hydraulic
Lawn swings
Lodge furniture
Mandolin bodies
Mandolin necks
Matches
Moldings (piano cases)
Music cabinets (inside work)
Organ parts (interior)
Organ pipes
Packages (fruit and vegetable)
Panels (automobile bodies)
Panels (vehicle bodies)
Panels (veneered)
Passenger cars (interior work)
Patterns
Pedestals
Peels (bakers')
Piano parts
Picture moldings
Pipe organs (interior parts)
Pool tables
Porch columns
Pulpits (church)
Pumps
Railway motor car parts
Refrigerators
Rollers (farm machinery)
Sash
Screen doors
Seats (automobile)
Seats (buggy)
Seats (carriages)
Seats (water closets)
Seeder boxes (farm implements)
Separator sides (threshers)
Sewing machine parts
Sideboards (built in)
Siding (grain grinders)
Siding (Ry. refrigerator cars)
Siding (wagon beds)
Somnols

Stacker parts (farm machinery)
Tables (cafe)
Tables (dining)
Tables (kitchen)
Telephones
Threshing machines
Troughs (bakers')
Trunks
Type cabinets
Vane slats (windmill)
Veneer cores (organ cases)
Veneer cores (piano)
Wardrobes (inside)
Washing machines (laundry)
Well machinery
Wheel slats (windmill)
Window screens
Woodenware
Zither bodies

REDWOOD

Redwood *(Sequoia sempervirens)* is a very soft, light, straight-grained softwood of great size and durability. Redwood is the strongest in proportion to its weight of any wood so far tested by the United States Forest Service. While in cross-breaking strength it is surpassed by a number of the stronger softwoods, redwood ranks close to longleaf pine in resistance to end-crushing.

Redwood finds its largest use in general building, and especially for siding and shingles, where its great durability is especially desir-

TABLE 99

Factory Uses of Redwood

Purpose	Per cent
Mill Work	78
Pumps and Wood Pipe	7
Tanks and Silos	7
Woodenware and Novelties	3
Boxes and Crates	2
Caskets and Coffins	1
Furniture and Fixtures	1
Other Uses	1
Total	100

able. Redwood is also much used for mill work because of its comparative freedom from swelling and shrinking with atmospheric changes, after it is once thoroughly seasoned.

The more important factory uses reported for redwood are as indicated in Table 99.

Other common uses for redwood are for:

Boat finish	Molding
Caskets	Musical instruments
Cabinets	Patterns
Coffins	Porch columns
Dairymen's supplies	Sash
Doors	Signs
Flasks	Silos
Fixtures	Tanks
Incubators	Windmills
Interior finish	

SASSAFRAS

Sassafras *(Sassafras sassafras)* is a soft hardwood of medium weight and much durability. The supply of sassafras lumber is not large, but it serves good purposes where available. Nearly all of it goes into various forms of mill work, and a small proportion into furniture and fixtures.

The reports indicate that sassafras is also used to some extent in the manufacture of novelties, souvenirs, and woodenware.

SPRUCE

Like the term "cedar," the word "spruce" covers a number of species both Eastern and Western. Important from the wood-using stand-

point are the red spruce *(Picea rubens)*, which is abundant in New England, and extends southward on the mountain ranges as far as North Carolina; black spruce *(Picea mariana)*, which occurs in the northern part of the range of the red spruce and in the Lake States; and white spruce *(Picea canadensis)*, which is the principal spruce of the Lake States. These species are the largest source of wood for paper pulp, and also furnish all the spruce lumber manufactured in the East. In the Rocky Mountain region, the spruce which is most manufactured into lumber is Engelmann spruce *(Picea engelmanni)*; while, in the Pacific Northwest, Sitka spruce *(Picea sitchensis)* is the chief source of spruce lumber. Of all these species, red spruce and Sitka spruce are by far the most abundant and important.

The wood of the spruces is very light in weight, soft, even-grained, and easily worked, even exceeding white pine in this respect. Spruce is stiff and strong in proportion to its weight. One

TABLE 100

Factory Uses of Spruce

Purpose	Per Cent
Mill Work	44
Boxes and Crates	42
Musical Instruments	4
Woodenware, Novelties, etc.	4
Tanks and Silos	1
Other Uses	4
Total	100

of the most exacting demands among the industries is that of wood for piano sounding boards; and for this purpose spruce has long been the chief supply. Recently spruce has found a new use in the manufacture of aeroplanes.

The factory uses reported for spruce without distinction of species are indicated in Table 100.

Eastern spruce is credited in the reports with being used in the manufacture of:

Agricultural implements
Aeroplanes
Boats
Boat oars
Bowling alleys
Boxes
Broom handles
Bungs
Butter tubs
Cable reels and spools
Cameras
Canoes
Car sheathing
Crates
Doors
Elevator platforms
Farm machinery
Fiber board
Fixtures, backing
Fixtures, linings
Fixtures, office
Fixtures, store
Flag poles
Flooring
Furniture (hidden parts)
Guitars
Hay presses
Ice boxes
Interior finish
Keyboards
Ladder sides
Mandolins
Match cases
Moldings
Molding flasks
Musical instruments
Novelties
Organ pipes
Paddles
Patterns
Piano backs
Piano benches
Piano cases
Piano ribs
Piano sounding-boards
Pipe organs
Player actions
Refrigerators (inside partitions)
Scaffolding
Ships
Shiplap
Silos
Skids
Sleds
Spars
Tables (ironing)
Tables (folding)
Tanks
Tubs
Vehicles
Woodenware

Sitka spruce is used for:

Apparatus (playground)
Balusters (porch)
Baskets
Blinds
Boxes
Breadboards
Brooders (poultry)
Caskets
Cornice brackets
Decking (boats)
Door frames
Doors
Furniture
Fixtures
Ironing boards
Ladders
Organ parts
Organ pipes
Porchwork
Pulleys
Refrigerator rooms
Refrigerators
Ribs (mandolin)
Ribs (piano)
Rims (guitar)
Sash
Scale parts
Siding (wagon beds)
Sounding-boards
Sounding-boards (guitar)
Spars (boats)
Store fronts
Trunks
Washboards
Wheel slats (windmill)
Windmill parts
Window frames
Woodenware

SYCAMORE

Sycamore *(Platanus occidentalis)* is a tough, strong wood, difficult to split. It has a beautiful figure when quarter-sawed, and would find

TABLE 101

Factory Uses of Sycamore

Purpose	Per Cent
Boxes and Crates	64
Furniture and Fixtures	12
Mill Work	7
Butchers' Blocks	6
Woodenware and Novelties	2
Refrigerators and Kitchen Cabinets	1
Musical Instruments	1
Agricultural Implements	1
Brooms and Carpet-Sweepers	1
Other Uses	5
Total	100

a much larger use were not the supply so limited.

The chief uses reported for sycamore are indicated in Table 101.

Sycamore is used to some extent in the manufacture of:

Barber poles
Barrels (veneer)
Basket parts
Baskets (fruit)
Baskets (vegetable)
Beds (folding)
Boat parts (row)
Boxes
Box shooks
Brush blocks
Butcher blocks
Cabinet work
Cigar boxes
Cooperage stock
Crating
Doors
Fixtures (office)
Flooring
Furniture
Guitar bodies
Handles
Hoppers (fruit and vegetable)
Horses (merry-go-round)
Ice boxes
Interior finish
Mandolin boxes
Meat blocks
Merry-go-round parts
Packages (fruit and vegetable)
Panels
Piano backs
Picture mouldings
Refrigerators
Tobacco boxes
Trunks
Vehicle bodies
Veneer cases (piano)
Washing machines

TAMARACK

With the exception of longleaf pine, tamarack *(Larix laricina)* is the heaviest and one of the strongest and toughest softwoods. It is rated among the more durable woods, and finds its largest use for general building purposes, and especially for heavy timbers.

Lumber from Eastern tamarack is manufactured chiefly in the Lake States; while the Western tamarack, or larch *(Larix occidentalis)*, is

produced chiefly in the region known as the "Inland Empire"—a section of common commercial interests comprising western Montana, northern Idaho, and eastern Washington.

Larch is a close-grained, heavy softwood of moderate strength and stiffness.

The government reports indicate that the factory uses for tamarack and larch, without distinction as to species, are as shown in Table 102.

TABLE 102

Factory Uses of Tamarack

Purpose	Per Cent
Mill Work	77
Tanks and Silos	8
Boxes and Crates	6
Paving and Conduits	4
Car Construction	1
Other Uses	4
Total	100

Eastern tamarack is used to a greater or less extent for:

Car construction
Boat floors
Boat keels
Boat stringers
Boxes
Ceiling
Crating
Culm pipe (mines)
Excelsior
Flooring
Interior finish
Molding
Pails
Refrigerators
Ship knees
Silos
Tanks
Tubs
Water pipes
Windmills
Woodwool

Western tamarack or larch is used for general building purposes, interior finish, boat frames,

keels, ribs, planking, and decking, door and window casing, fruit and butter boxes, etc.

TUPELO

Tupelo *(Nyssa aquatica)* is one of the softer hardwoods of medium weight, close-grained and difficult to split, but with very good working qualities. It grows chiefly in the cypress regions, and is manufactured and graded by the same interests as cypress. Only recently has tupelo come into general notice, but its progress has been rapid, as will be seen from its present factory uses as indicated in Table 103.

TABLE 103

Factory Uses of Tupelo

Purpose	Per Cent
Boxes and Crates	58
Mill Work	13
Tobacco Boxes	8
Woodenware and Novelties	4
Sewing Machines	3
Laundry Appliances	3
Furniture	3
Agricultural Implements	1
Other Uses	7
Total	100

More detailed uses of tupelo include:

Axles	Cigar boxes
Balusters	Clothespins
Baskets	Coffins
Berry cups	Crating
Boxes	Chairs
Brushes	Excelsior
Cabinets	Felloes
Ceiling	Flooring

Furniture
Hoppers
Hubs
Interior finish
Kitchen safes
Lard dishes
Laundry appliances
Molding
Musical instruments
Ox yokes
Panels (carriage)
Spokes
Table legs
Tobacco boxes
Trunks
Wagon bottoms
Wagon tongues
Washboards
Woodenware

BLACK WALNUT

The properties of black walnut *(Juglans nigra)* are too well known to need detailed mention. Black walnut is valued for its rich color, fine figure, and susceptibility to high polish. The most prized effects are produced by the careful manufacture of veneer from the burls and apparent deformities of the tree; and raw material of this character is so valuable as to be sold by the pound instead of the ordinary method of measurement.

TABLE 104

Factory Uses of Black Walnut

Purpose	Per Cent
Sewing Machines	33
Musical instruments	21
Mill Work	19
Furniture and Fixtures	10
Firearms	7
Caskets and Coffins	2
Electrical Machinery and Apparatus	2
Vehicles	2
Car Construction	1
Other Uses	3
Total	100

Considerable of the best black walnut is exported to Europe in log form. The factory uses reported for walnut in the United States are in the proportions indicated in Table 104.

Black walnut enters more or less into the manufacture of these articles:

Air-gun stocks
Altars
Automobile bodies
Barber chairs
Benches
Billiard cues
Bookcases
Brush backs
Bureaus
Cabinet work
Canes
Card tables
Carpet-sweepers
Carvings
Case work
Caskets
Chairs
Chair legs
China closets
Chiffoniers
Clock cases
Coffins
Couches (legs)
Desks
Doors
Electrical appliances (bases)
Embalming boards
Fixtures (exterior parts)
Fixtures, office
Fixtures, store
Fretwood
Furniture
Gunstocks
Handles
Inlaid work
Interior finish
Machine boxes
Molding
Novelties
Organ cases
Panels (veneered)
Parquetry flooring
Patterns
Pianos
Piano actions
Piano benches
Piano cases
Piano players
Picture frames
Pipe organs
Sash
Sewing machines
Show cases
Sideboards
Side tables
Steering wheels
Stools
Tables
Tool boxes
Umbrella handles
Vehicles
Windshields (automobile)
Woodenware

WILLOW

The wood of the willows which attain tree size

is very light and soft, and, while neither stiff nor strong, is tougher than many heavier woods.

Willow lumber is nearly all made from black willow *(Salix nigra),* and finds its largest use in the manufacture of boxes and crates. In bolt form, where abundant, willow is an important source of material for the manufacture of excelsior. Willow is also used in the manufacture of baseball bats, boats, furniture shelving, wagon beds, and artificial limbs.

YUCCA

In the Southwest, especially in Southern California, the yucca *(Yucca arborescens)* attains real tree dimensions, although this plant would not ordinarily be considered a tree at all. It appears that the equivalent of nearly 200,000 feet of lumber is annually manufactured from yucca. The wood is very light in weight, fibrous, tough, and, when wet, pliable and easily molded into desired forms.

Yucca finds its largest use in the manufacture of woodenware and novelties; but a considerable quantity is also used in mill work in California, and, in that State, it is used very much more than any other material in the manufacture of artificial limbs, jackets, surgeon's splints, and corsets.

MINOR SPECIES OF NATIVE WOODS

A few of the numerous other native woods used to a small extent include the following:

Ailanthus, mountain ash, and silver bell, for boxes and crates; blue beech, catalpa, and china tree, for vehicle parts; catalpa, china tree, kalmia, haw, mesquite, mulberry, and sumac, for furniture; manzanita, mountain lilac, mountain mahogany, and orange, for novelties; mulberry, silver bell, and witch-hazel, for millwork.

Since there are more than 500 tree species in the United States, it is obvious that, so far as numbers are concerned, only a few of them are mentioned in the foregoing pages. No species, however, has been omitted which is a considerable source of lumber supply or of much importance in general commerce. Many of the unmentioned woods are used in a small or local way for a large number of purposes, among which are novelties, turnery, etc.

FOREIGN WOODS

In the aggregate, the equivalent of about 100 million board feet of the more costly woods is used annually in the factories of the United States, principally for the manufacture of furniture and for the finer, more expensive mill work, as well as for various decorative purposes. The total quantity of each of these woods imported is divided among the various industries in about the proportions which are indicated in Table 105.

The only important foreign wood omitted from this table is Spanish cedar, of which about 30 million feet is imported annually and practically all used in the manufacture of cigar boxes.

TABLE 105

Factory Uses of Imported Woods

TURKISH BOXWOOD

Purpose	Per Cent
Whips, Canes, and Umbrellas	88
Firearms	6
Shuttles, Spools, and Bobbins	5
Other Uses	1
Total	100

WEST INDIAN BOXWOOD

Professional and Scientific Instruments	75
Shuttles, Spools and Bobbins	12
Musical Instruments	8
Handles	4
Other Uses	1
Total	100

COCOBOLA

Handles	75
Professional and Scientific Instruments	23
Other Uses	2
Total	100

EBONY

Whips, Canes, and Umbrellas	37
Sporting and Athletic Goods	36
Musical Instruments	11
Mill Work	9
Brushes	2
Tobacco Pipes	2
Furniture	1
Other Uses	2
Total	100

LIGNUM VITAE

Furniture	62
Sporting and Athletic Goods	25
Pulleys and Conveyors	8
Professional and Scientific Instruments	4
Other Uses	1
Total	100

MAHOGANY

Furniture and Fixtures	47
Musical Instruments	17
Mill Work	14
Car Construction	12
Caskets and Coffins	3
Ship and Boat Building	2
Vehicles	1
Other Uses	4
Total	100

PADOUK

Car Construction	52
Mill Work	24
Furniture and Fixtures	23
Other Uses	1
Total	100

PRIMA VERA

Furniture and Fixtures	52
Mill Work	32
Ship and Boat Building	8
Car Construction	7
Other Uses	1
Total	100

ROSEWOOD

Purpose	Per Cent
Professional and Scientific Instruments	46
Furniture and Fixtures	14
Musical Instruments	10
Car Construction	8
Sporting and Athletic Goods	5
Handles	8
Brushes	3
Bungs and Faucets	2
Artificial Limbs	2
Mill Work	1
Carpet-Sweepers	1
Other Uses	5
Total	100

SATINWOOD

Mill Work	50
Furniture and Fixtures	34
Musical Instruments	7
Caskets and Coffins	7
Other Uses	2
Total	100

TEAK

Ship and Boat Building	83
Mill Work	12
Car Construction	3
Sporting and Athletic Goods	1
Other Uses	1
Total	100

CIRCASSIAN WALNUT

Mill Work	43
Furniture and Fixtures	32
Musical Instruments	15
Firearms	3
Ship and Boat Building	1
Sporting and Athletic Goods	1
Carpet-Sweepers	1
Other Uses	4
Total	100

In addition to the foregoing, there are annually used on the Pacific Coast several million feet of foreign hardwoods, among the more important of which are Japanese oak and birch, Siberian oak, Philippine mahogany and other species, and Australian eucalyptus. Small quantities of many other foreign woods are also used for a variety of purposes.

Under normal conditions, considerable pine lumber manufactured in northern Mexico is shipped across the border, while a large amount of Canadian white pine is marketed in the United States.

FOREST PRODUCTS

THE annual wood consumption in the United States takes from our forests approximately 23 billion cubic feet of wood, allowing for the waste which occurs in logging and milling operations. In round numbers, we use yearly 100 million cords of firewood, 45 billion feet of lumber, nearly 15 billion shingles, over a billion posts, poles, and fence rails, 140 million cross-ties, over 2 billion staves, more than 150 million sets of heading, nearly 400 million barrel hoops, 3 million cords of domestic pulpwood, 165 million cubic feet of round mine timbers, over 1,200,000 cords of wood for distillation and more than 1,000,000 cords of tanbark.

LUMBER

The manufacture of lumber constitutes by far the largest single use of the forest. Big and little, there are nearly 50,000 sawmills in the United States. The making of lumber and timber products gives employment to more labor than any other industry in the country; while, in the point of capital invested and value of output, the manufacture of these products ranks third in our great industries—surpassed only by meat packing and the foundry and machine shop industries.

According to the Census of 1910, which was

by far the best canvass ever made of the industry, the total lumber production in 1909 was 44,509,761,000 board feet, by 48,112 mills. Arranged in the rank of production, the output of the States which cut over one billion feet each, and the number of mills in operation, were as indicated in Table 106.

TABLE 106

Number and Output of Sawmills in the United States

(Census of 1910)

States	No. of Sawmills	Million Board Feet
Washington	1,143	3,863
Louisiana	658	3,552
Mississippi	1,795	2,573
North Carolina	3,307	2,178
Arkansas	2,060	2,111
Virginia	3,511	2,102
Texas	719	2,099
Wisconsin	1,251	2,025
Oregon	696	1,899
Michigan	1,323	1,890
Alabama	2,188	1,691
Minnesota	745	1,562
West Virginia	1,524	1,473
Pennsylvania	3,054	1,463
Georgia	2,083	1,342
Tennessee	2,643	1,224
Florida	491	1,202
California	305	1,144
Maine	1,243	1,112
Other States	7,383	8,005
Total	48,112	44,510

As nearly as can be estimated, the present annual lumber cut from the leading species of timber, and the States in which each is chiefly manufactured are indicated in Table 107.

TABLE 107

Annual Lumber Production in the United States

Species	Million Bd. Ft.	Per Cent	Most Largely Produced in
Yellow Pine	16,000	35.9	La., Miss., Tex., N. C., Ala., Ark., Va., Fla., Ga., S. C.
Douglas Fir	6,000	13.5	Wash., Ore., Cal.
Oak	4,400	9.9	W. Va., Tenn., Ky., Va., Ark., Ohio
Northern Pine	3,000	6.7	Minn., Wis., Me., N. H., Mich.
Eastern Hemlock	2,500	5.6	Wis., Mich., Pa., W. Va.
Western Yellow Pine	1,400	3.1	Cal., Ida., Wash., Ore.
Maple	1,200	2.7	Mich., Wis., Pa., N. Y.
Eastern Spruce	1,100	2.5	Me., W. Va., N. H., Vt.
Cypress	1,100	2.5	La., Fla., Ga., Ark.
Yellow Poplar	800	1.8	W. Va., Tenn., Ky., Va., N. C.
Red Gum	800	1.8	Ark., Miss., Tenn., La.
Chestnut	650	1.4	W.Va., Pa., Va., Conn., N.C.
Redwood	525	1.2	California
Beech	475	1.1	Mich., Ind., Pa., Ohio, N. Y., W. Va.
Birch	425	1.0	Wis., Mich., Me., Vt., N. Y.
Western White Pine	400	.9	Ida., Wash., Mont.
Basswood	375	.8	Wis., Mich., W. Va., N. Y.
Cottonwood	350	.8	Miss., Ark., La., Mo.
Elm	325	.7	Mich., Wis., Ohio, Ind., Mo.
Western Larch	300	.7	Mont., Ida., Wash.
Western Spruce	300	.7	Wash., Ore., Col.
Western Hemlock	300	.7	Wash., Ore., Ida.
Hickory	300	.7	Ark., Tenn., Ky., Ohio, Ind.
Ash	275	.6	Ohio, Ark., Ind., Tenn., Wis.
Western Cedar	250	.6	Wash., Ida., Ore., Cal.
White Fir	140	.3	Cal., Ore., Ida.
Sugar Pine	140	.3	California
Tupelo	140	.3	La., N. C., Ala., Va.
Tamarack	125	.3	Minn., Wis., Mich.
Eastern Cedar	125	.3	Tenn., Va., Mich., Ala.
Balsam Fir	100	.2	Me., Minn., Vt., Mich.
Sycamore	55	.1	Mo., Ind., Ark., Tenn.
Walnut	45	.1	Ohio, Ind., Ky., Ill., Mo.

Cherry	25		W. Va., Penn., N. Y., Ohio
Buckeye	20		Tenn., W. Va., N. C., Ky.
Willow	20		Mississippi
Noble Fir	17		Oregon
Magnolia	10		Louisiana
Locust	6		Va., Penn., N. C.
Red Fir	5		California
Butternut	3		Tex., Ind., Wis.
Cucumber	3	.2	W. Va., Va.
Dogwood	3		Tenn., N. C.
Red Alder	3		Ore., Wash.
Persimmon	3		Tenn., Miss., Ark.
Hackberry	2		Ill., Mo., Ind., La.
Alpine Fir	2		Rocky Mt. region
Silverbell	1		Tennessee
Other Woods	7		
Total	44,550	100	

The quantity of lumber produced in the four leading regions since 1850 is shown graphically in Fig. 12 (page 320).

VENEER

The manufacture of veneer has developed greatly in the last few years, and will undoubtedly increase in the future, since the uses for thin lumber of this sort are rapidly expanding. While much high-class veneer is used for furniture, musical instruments, etc., there is a growing demand for heavy veneer for the manufacture of boxes, crates, cases, drawer bottoms and the like. This explains the large amount of veneer made from such woods as yellow pine and cottonwood. According to government reports, the amount of native timber used for veneer in the United States in 1910 was as indicated in Table 108.

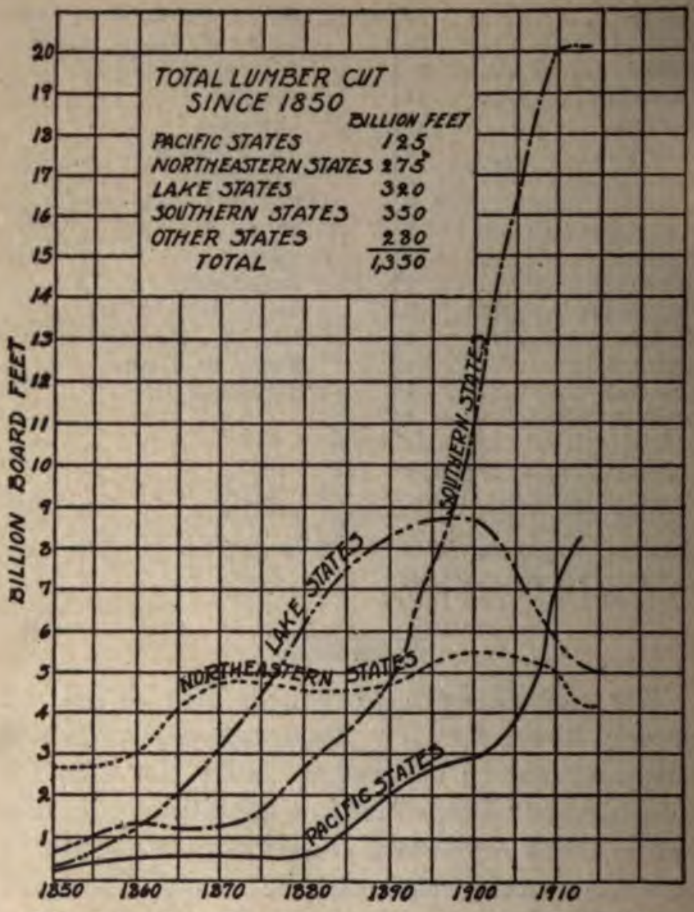


Fig. 12. Chart Showing Amount of Lumber Cut in the Various Sections of the United States since 1850

SHINGLES

Closely connected with lumber production is that of shingle manufacture. The Census of 1910 reported the shingle output to be as shown in Table 109.

of Cedar Shavings from a
Shingle Mill

Maple Last Blocks

ed Door of Curly Birch
aid with White Holly
and Black Walnut

Norway Pine and Paper Birch

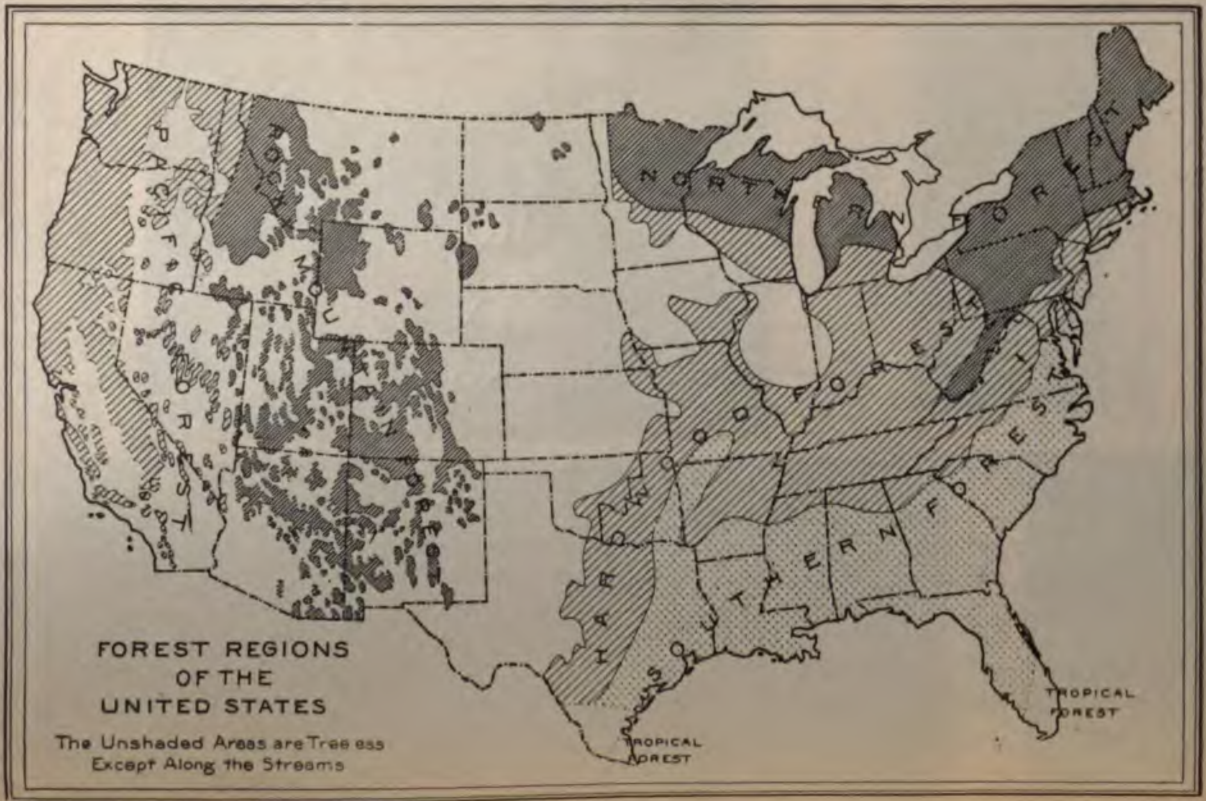


Plate 37—Lumber and Its Uses

TABLE 108

Wood Used for Veneer in the United States

(Census of 1910)

Species	M. Feet (Log Scale)
Red Gum	158,157
Yellow Pine	40,324
Maple	39,812
Yellow Poplar	33,812
Cottonwood	33,149
White Oak	33,005
Birch	27,623
Tupelo	26,548
Elm	17,272
Basswood	11,003
Beech	10,550
Red Oak	9,769
Spruce	6,271
Walnut	2,724
Sycamore	2,548
Ash	2,356
Douglas Fir	2,006
Chestnut	1,736
All Others	2,611
Total	460,495

TABLE 109

Production of Shingles in the United States

(Census of 1910)

Species	Shingles (Millions)
Cedar (Chiefly Western)	10,964
Cypress	1,387
Yellow Pine	1,294
Redwood	507
White Pine	283
Spruce	147
Chestnut	92
Hemlock	76
Western Pine	69
Other	90
Total	14,909

OTHER PRODUCTS

Cross-ties are cut chiefly from oak, yellow pine, Douglas fir, cedar, chestnut, cypress, tamarack, hemlock, Western pine, and redwood, in the order named, with 70 per cent of the total supplied by oak, yellow pine, and Douglas fir. Spruce, hemlock, and poplar form the leading pulpwoods. Slack barrel staves and heads are chiefly made from red gum, yellow pine, beech, elm, and maple; hoops, from elm; tight barrel staves and heads, from white oak. Two-thirds of the telephone and electric poles are of cedar, and the rest chiefly chestnut, oak, pine, and cypress. Wood alcohol is made by the destructive distillation of birch, beech, and maple; turpentine and rosin, by tapping longleaf pine trees and the distillation of the wood; and tannin is obtained from hemlock and oak bark and chestnut wood.

THE TIMBER SUPPLY

FOREST REGIONS

BOTANISTS and foresters subdivide the United States into five great forest "regions" characterized by fairly definite forest types. These are the Northern, Central, Southern, Rocky Mountain, and Pacific regions.

The Northern Forest. The Northern forest type extends from Maine across New England, New York, Michigan, and Wisconsin, to western Minnesota, with a prolongation down the southern Appalachians to the northern edge of Georgia. Originally the coniferous type predominated in the Northern forests, and by far the most important species was white pine. Next to white pine, ranked hemlock, which was especially abundant in Pennsylvania, Michigan, and Wisconsin; and associated with these species was Norway pine, spruce, cedar, balsam, and a large variety of hardwoods, the most important of which were maple, birch, basswood, beech, ash, and elm.

The Southern Forest. Starting in New Jersey, and extending to the south and west over practically all of the Atlantic and Gulf States to Texas, with a prolongation up from Texas across Arkansas to Southern Missouri, is the Southern type of forest, in which the yellow pines predominate, with longleaf pine the most

abundant of any single species. In many localities within the pine belt, hardwoods are plentiful, especially the gums; while in the swampier regions, and particularly in Louisiana and Florida, large quantities of cypress are found.

The Hardwood Forest. Lying between the Northern and Southern Forest, and reaching from the Atlantic seaboard to the Missouri river, is a great, irregular region in which the hardwoods abound to the exclusion of other species. It was here that the oaks, elms, hickories, walnut, yellow poplar, sycamore and other hardwoods were originally most abundant and attained their finest development. It is here, also, that the clearing of forests for agricultural development has gone the farthest, since hardwoods are generally found upon the richest types of agricultural soils. However, the farm woodlots and many areas of larger size in this region still yield much timber for local use, and considerable for shipment to more distant markets.

The Rocky Mountain Forest. Passing over the vast forestless area of the prairies and plains, we come to the Rocky Mountain region, with coniferous forests on most of its higher mountain slopes and plateaus. The bulk of the timber in these forests consists of Western yellow pine, with other pines, firs, and spruces, and—in the northern Rocky Mountain region—considerable quantities of larch, Western hemlock, cedar, and Western white pine.

The Pacific Forest. On the Pacific Coast are found the heaviest stands of timber, and the largest individual trees ever recorded in history or revealed by geological strata. From the summits of the Cascades to the Pacific ocean in Oregon and Washington, and on the Coast range and the Sierras of California, are giant firs, cedars, spruces, redwoods, and pines, which for many years to come will be the most important source of timber supply for a large portion of the United States.

The forest regions are outlined in Plate 37.

AREA AND STAND

The best estimates indicate that the forest areas, and the quantity of standing timber available according to present standards of utilization, within these five regions, are not less than the amounts shown in Table 110.

TABLE 110

Forest Areas and Quantity of Standing Timber in the United States

Forest Regions	Area (Million Acres)	Stumpage (Billion Feet)
Northern	90	270
Southern	150	630
Central	130	300
Rocky Mountain	100	300
Pacific	80	1,300
Total	550	2,800

As nearly as can be estimated on the basis of present knowledge, our 2,800 billion feet of

standing timber is divided among the various species as indicated in Table 111.

TABLE 111

Quantity of Standing Timber of Various Species

Species	Billion Feet
Douglas Fir	650
Western Pine	475
Southern Pine	375
Western Hemlock	150
Redwood	100
Western Cedar	75
Sugar Pine	60
Othern Western Softwoods	85
Cypress	40
Other Eastern Softwoods	190
Hardwoods	600
Total	2,800

FOREST OWNERSHIP

Three main types of ownership hold our 550 million acres of forest land. These are public forests, farm woodlots, and the larger private holdings. Public forests include the State and National Forests and Parks, and timber on the unreserved public domain and on military and Indian reservations.

The National Forests aggregate about 160 million acres, and are chiefly in the Rocky Mountain and Pacific States. They were created by the withdrawal of public land from private entry and sale. Within the last few years, however, the National Government has entered upon the policy of purchasing timber lands in the Eastern mountains, where forest growth is considered

necessary for the protection of watersheds at the heads of navigable streams. Under this policy, extensive purchases of forest land (chiefly cut over) are being made in the White Mountains and the southern Appalachians.

The principal state forests are in the East. New York has approximately 1,500,000 acres in its State Park. Pennsylvania has something like a million acres in forest reserves; Wisconsin, about 400,000 acres; and a few other States, comparatively small forest reservations.

The farm woodlots amount to about 190 million acres. As their name implies, these tracts are chiefly the smaller areas of timber land owned by the farmers in the eastern half of the United States. They average, perhaps, 30 acres in area, and, while not a large source of commercial timber supply, are very important for local use. The Census placed the value of their output in 1909 at 195 million dollars.

The third type of forest ownership is that of the larger private holdings, amounting to about 200 million acres, and contains at least 75 per cent of the merchantable standing timber in the country. Naturally, these holdings in general contain the best of the standing timber in the United States, since private capital always seeks the best investment.

A TIMBER FAMINE?

There has been much talk to the effect that a timber famine is impending in the United

States. Whether this is true or not depends entirely upon what is meant by the term "famine." If it means that our timber supply will be completely exhausted in 30, 40, 50, or even 100 years, then we can say positively that there will be no timber famine. If, on the other hand, the term means that, compared with present conditions, our supply of standing timber will be reduced, and the price of lumber higher within the lifetime of men now living, then we can say with equal truthfulness that there will be a timber famine. The question is purely a relative one. Up to the present time, timber of almost every species and grade has been cheap and abundant. In the future, some kinds will be scarcer, and some grades higher priced. On the other hand, there will be a comparatively large supply of the common grades of building lumber for many years, and the competition of other materials will be a strong factor in holding prices to a level which will make most forest products available for a multitude of purposes.

Such data as can be secured indicate that the amount of timber now standing in the United States, estimated at 2,800 billion feet, is perhaps one-half the quantity that existed in the country before clearing for settlement and cutting for lumber began. Our annual consumption of sawed timber products now averages approximately 50 billion feet a year. If the stand is 2,800 billion feet, it furnishes cutting for 56 years at the present rate. As a matter

of fact, however, more than 2,800 billion feet of lumber will be sawed from the present stand of timber. In some regions there will also be no inconsiderable increment through natural reproduction or growth. Our annual per capita consumption of lumber, which has been ranging close to 500 board feet, will eventually drop somewhere near to the German level of only 48 board feet. This will greatly reduce the demand upon our remaining supply of timber, and help make it sufficient for all legitimate needs.

These statements do not imply that there should be any lack of effort to protect our forest resources. On the contrary, they require the expenditure of great sums of money and years of patient care to bring them into proper condition. The conservation of our natural resources means making the best possible present use of them, while safeguarding their reproductive power for the future. Fortunately, our forest resources are easily reproduceable. The question of forestry is largely one of the best utilization of land surface. Land which will yield the highest return under agriculture will, through economic development, find its use in agriculture. Land which will yield the best return when forested—and this includes land chiefly incapable of ordinary forms of cultivation—will ultimately be the source of our timber supply.

So far as present knowledge permits the classification, it is believed that our forest area

of 550 million acres contains 200 million acres of practically mature timber; 250 million acres partially cut and burned over, on which there is sufficient natural reproduction to insure a fair second growth; and, finally, 100 million acres so severely cut and burned that, unless supplemented by planting, there will be no succeeding forest of commercial value.

Our potential forest area is large enough to supply all the timber of every kind that we need if it is rightly handled. Here is a field which for years to come will afford great opportunity for the activities of both statesmen and foresters. Although four-fifths of the present timber supply is privately owned, it is highly probable that 100 years hence the bulk of the timber then existing will be in public forests. Because of the long-time investment required, the hazard involved, and the relatively low interest rate obtained from forestry, private capital is not likely to engage in timber growing on a large scale. This makes it necessary that eventually the National and State Governments shall become the more important timber owners.

PERMANENT ADVANTAGES OF WOOD

THE clever and persistent advertising given to many substitutes for wood and timber might lead the reader to think that in a few years lumber will be either unnecessary or unobtainable. Wooden sidewalks went out of fashion long ago; wooden buildings and shingle roofs are not permitted in restricted sections of cities; boxes of paper and fiber are used in place of boxes formerly made of boards; steel passenger and freight cars and concrete culverts and bridges are common; while structures of concrete, brick, or tile are found on the farms, and steel row-boats glide about the pleasure parks. As a matter of fact, wood has been so cheap and abundant in the United States that it has been used for a multitude of temporary purposes, and often for purposes for which other products are better suited.

Another stage of economic development has now been reached. Wood is taking its place as one of the finer materials, and the coarser uses are being given over to coarser products. This makes it possible to have a relatively larger supply of wood for the purposes for which it is unquestionably the most suitable material. No doubt, also, some of the present use of substitutes is a temporary fad, and public favor will

eventually return sensibly to the earlier material.

The permanent advantages offered by wood may be summed up as follows:

(1) Its general availability. Wood is a natural product more widely distributed and more easily obtainable than any other structural material which the earth affords. The multiplicity of purposes for which it is used is surprising, even to those best informed upon the subject. A recent study of the wood-using industries of Illinois showed that in the factories of that State white oak is used for 276 distinct purposes; that hard maple has 164 functions in these same factories; that birch is used in the manufacture of 154 different articles; and that red oak, longleaf pine, red gum, yellow poplar, white pine, and basswood are each used for 100 to 140 different purposes. Moreover, the new uses developed for wood yearly through discovery and invention, offset to some extent the lessened demand because of substitutes in other directions. For example, the use of wood block paving is rapidly increasing.

(2) Wooden structures can be altered and moved, or built over, more easily and cheaply than can structures of any other material.

(3) Wood is very strong for its weight, compared with other structural materials. The average weight of the woods ordinarily used is some 30 pounds per cubic foot; that of iron and steel is 14 to 15 times as much. This is a great advantage in handling. A bar of hickory greatly surpasses in tensile strength a bar of steel of the same weight and length. Similarly, a block of hickory or longleaf pine will sustain a much greater weight in compression than a block of wrought iron of the same height and weight. Indeed, practically any piece of sound, straight-grained, dry wood is stronger than steel, weight for weight. Moreover, wood will sustain a far

greater distortion of shape than metal, without suffering permanent injury; while, of course, no such distortion can be sustained by either concrete or clay products.

(4) Wood is easily worked with common tools, while to work the metals requires special tools and much power and time. Anyone with saw and plane and auger can build a structure of wood; an ironworker is a skilled mechanic whose services come high.

(5) Wood is a non-conductor of heat and electricity, as compared with metal; and of moisture, as compared with ordinary concrete and brick. These are points for serious consideration in home building. They also explain why we prefer to sit on wooden seats, work at wooden desks, and eat at wooden tables.

(6) Wood does not contract and expand with changes of temperature, while its tendency to shrink and swell with atmospheric conditions can be completely overcome by proper seasoning and painting; hence wood can be made to "stay where it is put."

(7) Wood has a varied and beautiful figure with which no other material can hope to compete, for furniture, house trim, and general decorative purposes. It gives a comfortable, homey atmosphere that can be obtained in no other way.

(8) Wood offers a combination of strength, toughness, and elasticity not possessed by any other material. Imagine, if one can, a base ball bat, a golf club, or an ax handle of anything but wood.

No matter how great may be the inroads of substitutes, wood will continue to be an essential component of articles of necessity, of luxury, and of sport. We shall always have it with us, and such increase in its cost as may be brought about by natural causes will only serve to make the many intrinsic qualities of wood more highly appreciated.

SOURCES OF INFORMATION ABOUT TIMBER

THE general public has little idea of our timber supply, and even the manufacturers and users of forest products have no conception of the abundance of information that can be obtained simply for the asking. The Forest Service of the United States Department of Agriculture has for many years collected information upon the forest resources of the United States, and upon the properties and uses of wood, which is freely given to all inquirers. Moreover, the several associations of lumber manufacturers throughout the country freely supply information upon their own particular products.

ASSOCIATIONS OF LUMBER MANUFACTURERS

The more important of the associations of lumber manufacturers, together with their headquarters and the woods with which they deal, are given on page 38. In addition to setting standards for lumber grades and sizes, these associations are valuable sources of information upon trade customs and the uses of lumber. They are not selling organizations; but an inquiry directed to them will promptly bring

a reply stating where and of whom any given product may be purchased. Several of the associations conduct extensive advertising campaigns to increase the demand for their products; and from them the prospective timber user may obtain a great deal of interesting information put up in attractive form, as well as samples of the various woods, from which their quality and structure may be judged.

THE NATIONAL FORESTS

The National Forests contain one-fifth of the present timber supply of the United States, and will become increasingly important as time goes on, since they are so managed as to insure a permanent timber crop. All timber which can be cut from the National Forests without impairing watershed protection, or a future crop of timber, is freely offered for sale. The location of these forests is indicated on the map in Plate 38. The magnitude of the government timber holdings, and their potential supply of forest products, are but little appreciated by the general public. Every forest is in charge of local officers, who execute the regulations as to timber cutting, stock grazing, etc., and among whose chief duties is the protection of the timber from fire.

The National Forests are divided into six main groups for administrative purposes. Inquiries concerning them may be addressed in each case to the District Forester nearest to the locality

Forest Products Laboratory, Madison, Wis. Operated by the Forest Service, U. S. Department of Agriculture, in Co-operation with the University of Wisconsin

Plate 39—Lumber and Its Uses

Another series of tests is upon axles, spokes, cross-arms, poles, and other manufactured articles, for the purpose of demonstrating the fitness of various species and grades of material for these uses.

The fourth series of mechanical tests is for the purpose of studying the effect of preservative treatments, methods of seasoning, fireproofing, and similar processes, upon the properties of wood.

Physical Properties of Timber

A knowledge of the physical properties of wood is necessary in a large number of industries, and essential to the investigation of problems relating to the seasoning and preserving of timber. The physical properties of wood which are given especial attention at the Madison laboratory include density, shrinkage, heat conductivity, and ability to absorb water and other liquids. The seasoning of timber is probably the most important single step in the transformation of wood into usable form, and much material is annually lost because of poor seasoning methods. It is the purpose of the Service investigations to assist in the introduction of better methods of seasoning; and much has been accomplished, especially in the devising of a scientific dry-kiln.

Another important line of study is that of the relation of the structure of wood to its physical properties. This is a subject upon which there is far too little information. For example: Two pieces of white oak of apparently like quality, from adjacent trees, were recently received at Madison. So far as could be determined by all ordinary means, the two pieces should have been of equal strength; yet, when tested, one piece was found to be twice as strong as the other. There seemed to be no explanation for this peculiar result until sections of the two pieces of wood were put under the microscope, when it was quickly discovered that the fibers of the stronger piece were twice as long as the fibers of the weaker

piece. This was a peculiarity of the growth of an individual tree, just as one boy of a family may be stronger than another, although the two are reared under exactly the same conditions.

Wood Preservation

The statisticians say that 126,000,000 cubic feet of wood were given preservative treatment in 1912; so there is no need to discuss the importance of a thorough understanding of timber-treating materials and the processes by which they are applied. The work of the Service laboratory along this line has already been very extensive, and recently it has gone a step further to include a study of methods by which wood may be rendered fireproof. Legislation against wood as a building material in cities is becoming so general that it will be completely banished from many places where it is most useful and economical unless a method can be devised of making wood fireproof at reasonable cost.

Co-Operation with the Public

It is the policy of the Forest Products Laboratory to secure as fully as possible the co-operation of the industries most directly concerned with the problems under investigation. In some cases, where the resulting work is of much value to the co-operating firm, a charge to cover part of the cost is made by the Service; in other cases, where the investigations are of an experimental nature and of general value, the services of the laboratory are entirely free. At all times, the laboratory furnishes, either by letter or through its publications, much useful information upon a wide variety of subjects.

The officers in charge of the laboratory are of the highest type of public servants whom it is always a pleasure to meet or to correspond with. Any manufacturer of forest products or consumer of wood who has difficulty of any kind

in the handling of his material, will find it worth while to lay his problems before the Forest Service experts. The chances are that he will get help, and get it promptly.

FOREST SERVICE PUBLICATIONS

Questions relating to the quantity, kind, and distribution of the timber supply of the United States, to the annual output of lumber and other forest products, to forest planting, to forest management, and to the National Forests, should be directed to the United States Forest Service, Washington, D. C. Such inquiries always receive prompt and courteous attention. Moreover, the following publications of special interest to the users of forest products can be obtained from the Government Printing Office at the nominal price mentioned.

Remittance should be made to the Superintendent of Documents, Washington, D. C., by postal money order, express order, or New York draft. If currency is sent, it will be at sender's risk.

Postage stamps, foreign money, uncertified checks, defaced or smooth coins, will positively not be accepted.

Forest Service Bulletins

No.
10. Timber. Elementary discussion of characteristics and properties of wood. 10c.
13. Timber Pines of Southern United States. With discussion of structure of their wood. 50c.

17. Check List of Forest Trees of the United States, their Names and Ranges. 15c.
33. Western Hemlock. 30c.
36. Woodsman's Handbook. 25c.
37. Hardy Catalpa. 1, Hardy catalpa in commercial plantations; 2, Diseases of hardy catalpa. 40c.
40. New Method of Turpentine Orcharding. 20c.
41. Seasoning of Timber. 25c.
42. Woodlots. Handbook for owners of woodlands in southern New England. 15c.
50. Cross-Tie Forms and Rail Fastenings. With special reference to treated timbers. 15c.
58. Red Gum. With discussion of mechanical properties of red gum wood. 15c.
64. Loblolly Pine in Eastern Texas. With special reference to production of cross-ties. 5c.
70. Effect of Moisture upon Strength and Stiffness of Wood. 15c.
73. Grades and Amount of Lumber Sawed from Yellow Poplar, Yellow Birch, Sugar Maple, and Beech. 10c.
75. California Tanbark Oak. 15c.
78. Wood Preservation in the United States. 10c.
80. Commercial Hickories. 15c.
81. Forests of Alaska. 25c.
82. Protection of Forests from Fire. 15c.
83. Forest Resources of the World. 10c.
84. Preservative Treatment of Poles. 15c.
88. Properties and Uses of Douglas Fir. 15c.
95. Uses of Commercial Woods of the United States. Part I—Cedars, Cypresses, and Sequoias. 10c.
99. Uses of commercial woods of United States. Part II—Pines. 15c.
104. Principles of Drying Lumber at Atmospheric Pressure. With humidity diagram. 5c.
105. Wood Turpentines. 15c.
106. Wood-Using Industries and National Forests of Arkansas. 5c.
107. Preservation of Mine Timbers. 10c.
108. Tests of Structural Timbers. 20c.
115. Mechanical Properties of Western Hemlock. 15c.
116. Possibilities of Western Pines as Sources of Naval Stores. 10c.
117. Forest Fires. 10c.

118. Prolonging Life of Cross-Ties. 15c.
122. Mechanical Properties of Western Larch. 10c.
126. Experiments in Preservative Treatment of Red-Oak and Hard-Maple Cross-Ties. 20c.

Forest Service Circulars

No.
36. Forest Service, What It Is, and How It Deals with Forest Problems. 5c.
40. Utilization of Tupelo. 5c.
46. Holding Force of Railroad Spikes in Wooden Ties. 5c.
102. Production of Red Cedar for Pencil Wood. 5c.
111. Prolonging Life of Mine Timbers. 5c.
132. Seasoning and Preservative Treatment of Hemlock and Tamarack Cross-Ties. 5c.
136. Seasoning and Preservative Treatment of Arbor Vitae Poles. 5c.
140. What Forestry Has Done. 5c.
141. Wood Paving in the United States. 5c.
142. Tests of Vehicle and Implement Woods. 5c.
146. Experiments with Railway Cross-Ties. 5c.
147. Progress in Chestnut Pole Preservation. 5c.
151. Preservative Treatment of Loblolly Pine Cross-Arms. 5c.
164. Properties and Uses of Southern Pines. 5c.
166. Timber Supply of the United States. 5c.
177. Wooden and Fiber Boxes. 5c.
179. Utilization of California Eucalyptus. 5c.
187. Manufacture and Utilization of Hickory. 5c.
189. Strength Values for Structural Timbers. 5c.
192. Prevention of Sap Stain in Lumber. 5c.
193. Mechanical Properties of Redwood. 5c.
194. Progress Report on Wood-Paving Experiments in Minneapolis. 5c.
200. Absorption of Creosote by Cell Walls of Wood. Forest Products Laboratory Series. 5c.
206. Commercial Creosotes. With special reference to protection of wood from decay. Forest Products Laboratory Series. 10c.
210. Yield and Returns of Blue Gum, Eucalyptus, in California. 5c.
211. Greenheart. 5c.

212. Circassian Walnut. 5c.
213. Mechanical Properties of Woods Grown in the United States. Forest Products Laboratory Series. 5c.
214. Tests of Packing Boxes of Various Forms. Forest Products Laboratory Series. 5c.

There is no reason why any person who intends to use wood for any purpose may not learn promptly and authoritatively the best wood to use, and where to get it, if he will take the trouble to address a letter to either the United States Forest Service or to the lumber associations mentioned in this book.

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LIST OF PLATES

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